Thyme Production Line

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Abstract

The agriculture plays an important role in the national incoming within the Palestinian territories; Thyme is one of the most used herbs in the local market. It is commonly used in food and medical industries, it also considered as a principal element of the traditional Palestinian dishes (Palestine's culture).

Thyme crops harvesting and handling are done in traditional methods (i.e. manually), the traditional methods have several problems which include; long harvesting time, huge teamwork effort in post-harvesting handling (for instance, separating the leaves from branches).

To facilitate Thyme harvesting and post-harvesting processes, thyme harvester machine designed and thyme splitting machine designed and built.

These machines allow the farmers to sell thyme as a bundle or as leaves only.

In our project, the process automation used Programmable Logic Controller (PLC) unit for the automatic thyme splitting machine. A prototype of the automatic thyme splitting machine was constructed to demonstrate the process automation.

ملخص

تعد الزراعة في الأراضي الفلسطينية جزءا مهما جدا من الداخل القومي؛ و الزعتر من أهم المحاصيل التي يتم تسويقها في السوق المحلية. يستخدم الزعتر بشكل اساسي في المنتجات الغذائية وفي صناعة الأدوية وايضا يعد بحد ذاته جزءا مهما من العلاج بالأعشاب ، ويعتبر الزعتر من الوجبات التقليدية في الثقافة الفلسطينية.

حصاد الزعتر وتضميهم وفصل الاوراق عن الاغصان (التفريط) يتم حاليا بالطرق التقليدية اليدوية ،وهذه الطرق لها عدة سلبيات منها :تحتاج لوقت طويل عند الحصاد، جهد كبير،عدد كبير من الايدي العاملة ، بالإضافة الى الامراض التي تنتج عن الغبار خاصة في عملية التفريط .

في هذا المشروع ، تم تصميم ماكنة الحصادة، وتصميم وبناء ماكنة الفراطة. هذه الماكنات ستتيح للمزارع امكانية بيع المحصول اما على شكل ضمم زعتر او على شكل اوراق.

تم استخدام المتحكم المنطقي المبرمج في ماكنة الفراطة للتحكم في عملها. وتم بناء نموذج عملي لماكنة فرط الزعتر لتوضيح العمليات الاليه لها.

List of figures

List of tables

CONTENTS

CHAPTER ONE

Introduction

1.1 Introduction

Thyme is a historical traditional Palestinians food. Thyme plant is considered as one of the main important row material in medical use and nutrition as so. Thyme agriculture is widely spread along the Mediterranean countries especially in Palestine and Syria, wherea suited conditions for thyme cultivation exist.According to Palestinian central bureau of statistics; thyme cultivation is spread in Palestine as figure (1.1) show.

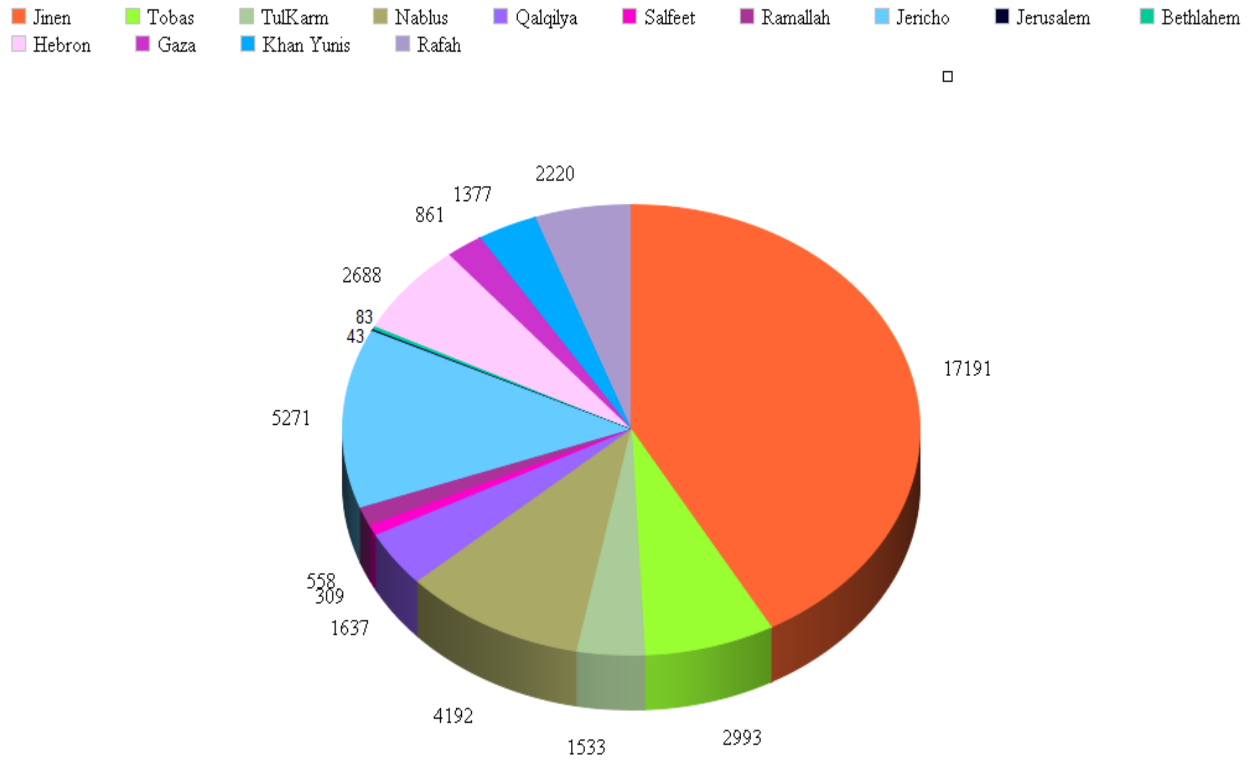


Figure (1.1): Field crop production in Palestine by governorate, 2010/2011 in metric ton.

Gulf countries and Jordan considered as the biggest consumption market in the Middle East, they are taking the first place in thyme trade, and they are the biggest importing countries for Palestine's thyme, where 85% of the Palestine's thyme production is exported to their markets.

Thyme cultivation in Palestine takes about 4000 to 5500Km^2. [1]Two main types of thyme are being cultivated in Palestine. First, the local type which lives up to 20 years. Second, hybrid type which lives 4 to 5 years. Both types are harvested 3 to 4 times annually. Local type is softer and has a less stem diameter than the hybrid type.

The harvested thyme stems have different characteristics that depends on the time of harvesting along the year. Table (1.1) illustrates the main differences.

Table (1. 1): Differences in thyme plant according to the time of harvesting.

Harvesting data	**Thyme stem Length(cm)**	**Production amount(Kg/Km^2)**
Jan and Oct	30 – 60	1500
Mar and Jun	10 – 30	80

1.2 Problem Statement

Traditional thyme harvesting process has many problems. It needs effort, time, and large number of workers which make it costly process. Moreover, this way leaves some of thyme stems without collection, due to the variation of the stems lengths and human errors. An additional problem is that the output of this process is not stacks, which mean another stage is needed to stack thyme.

Traditional thyme splitting process considered as serious problem, the workers face challenge which is removing the leaves without damaging the stem in order to have a pure leaves without any impurities. According to the traditional method, leaves with just 60% purity are achieved. Moreover, during the process the workers suffer from problems related to breathing issues, produced from the way that thyme is hit which makes dusty surrounding environment.

In order to overcome these problems, two machines will be designed, which are:

1. Thyme harvesting machine: used to harvest thyme and stack it at the same stage.
2. Thyme splitting machine: used to separate leaves from stems.

1.3 Goals and Objectives

Two machines will be design in order to achieve the goals:

- Increase the percentage amount of production of thyme by harvesting and collecting the maximum amount of it from the farms.
- Increase supplying thyme product to markets by producing it as stacks.
- To produce thyme leaves with high purity, with less crushed stems, by separating leaves out of stems using thyme splitting machine.

1.4 Project Scope

Project aims are to give a suggested design for a machine to harvest thyme, and to produce a machine to remove the leaves out of stems. Each machine contains many processes from input to output as illustrated in block diagrams in figure (1.2.a) and figure (1.2.b).

(A) Harvesting machine:

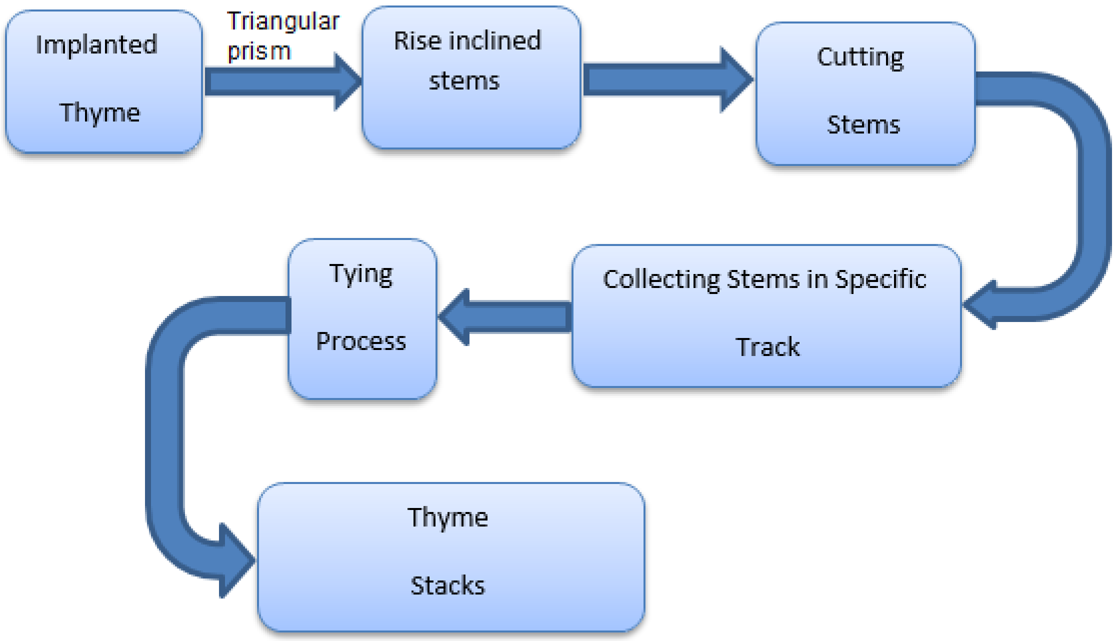


Figure (1.2.a):Block diagram of the harvesting process steps.

The process starts with rising the inclined implanted thyme stems. Second, forcing the middle and side plants to move along tracks. Third, cutting the stems and collect them in specific track. Fourth, the process of tying the stems and produce a stacked thyme stems is come.

(B) Thyme splitting machine:

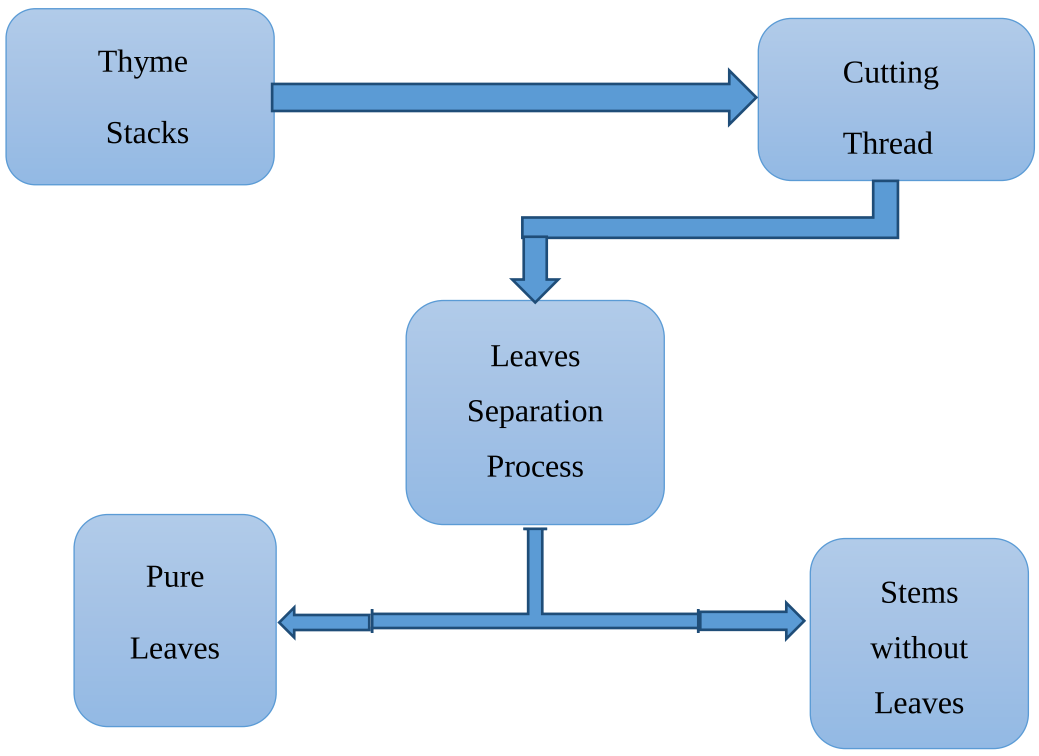


Figure (1.2.b):Block diagram of the splitting process steps.

Splitting process starts with receiving stacks from the worker, then cutting the thread of the stack because it will be converted to an individual stems , after that the process has to separate leaves from stems. The outputs of splitting process are: pure leaves and splatted stems.

1.5 Time Tables

Table (1. 2): Time table of the first and second semester.

Task / week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Literature Review														
Site visits														
Preliminary Design														
Sketch Up Prototypes														
Designs Simulation														

Testing Mechanisms														
Building Splitting Prototype														
Writing and documentation														
Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Determine Mistakes														
Generate Solutions														
Generate Alternative Designs														
Testing Mechanisms														
Build Adjusted Prototype														
Writing and Documentation														
Results and Conclusion														

1.6 Budget

Budget for thyme splitting machine:

Table (1. 3): Estimated budget for thyme splitting machine.

	Component name	Number of component needed	Price (NIS)	Total cost (NIS)	Descriptions
1	PLC	1	800	800	**Fatic (16/8 I/O)**
3	Pulley	12	50	600	**Aluminum diameter 22*φ 100mm**
4	Ball Bering	30	6	180	
5	Lift Conveyor	1	400	400	
6	V-Belt Conveyor	2	50	100	
7	Motors (AC)	5	300	1500	**3Ph 0.5Hp**

8	Brushes	4	50	200	
9	Steel for Body and Components	-	600	600	**0.04x0.04m** **hollow cross section**
10	Emergency Switch	1	25	25	
11	Position Switch (0-1)	3	25	75	
12	Position Switch (2-0-1)	1	20	20	
13	Push Button (Green & Red)	2	15	30	
14	Green Light	4	10	40	
15	Circuit Breaker (1-pole)	2	10	20	
16	Earth Leakage (RCD)	1	70	70	
17	Contactor ABB	5	80	400	
18	Over Load	5	100	500	
19	Board	1	400	400	
20	Gears	4	150	600	
21	Inverters	2	650	1300	**1PH input** **3PH output**
			Total price	**7920 (NIS)**	

CHAPTER TWO

State of the art

2.1 Introduction

This chapter contains a description of the traditional harvesting process and leaves splitting process as Thyme farmers describe it. The chapter contains also a description and conclusion of visits to the field which the work team performed to other crop harvesting such as wheat. The purpose of these visit was to find out if there is any similarity between thyme and wheat production processes. The chapter ends with the representation of the team visit to a factories to find out if there is any mechanisms that could be useful in the conceptual design stage.

2.2 Traditional Thyme harvesting process

Harvesting of thyme in Palestine is done by following a traditional (manual) method using sickle (منجل) which is a hand-held agricultural tool with a variously curved blade typically used for harvesting grain either freshly cut or dried as hay. The inside of the blade's curve is sharp, so that the user can swing it against the base of the crop, catching the stems in the curve and slicing them at the same time as shown in figures(2.1).

(a) Traditional harvesting method.

(b) Zoom view on the harvesting tool.

Figure (2. 1): Traditional harvesting method.

The traditional method has many disadvantages. First of all, it's not safe since a sharp side of the sickle tool has to be in touch with the hand of the farmer. Second, the production amount is very small as the worker action is relatively slow. Third, the process is affected by the bad weather, where the worker can't work in a rainy day since the soil becomes muddy and it limits the worker activity. Moreover, this traditional method is causing body back pain. The most important point that the sickle harvesting is not taking in consideration is the appropriate height of thyme to be cut, which lead to some part of Thyme remain uncut. So the method is hard, money, effort, and time consuming.

2.3 Post-harvesting thyme traditional process

Thyme production process passes through out many stages between harvesting and removing the leaves out of the stems. During traditional harvesting mentioned previous, farmers cut thyme and leave it on the ground, another farmer has to pass along the tracks to collect thyme in boxes as shown in the figure (2.2).

Figure (2. 2): Collecting Thyme in boxes.

Thyme boxes are transported to sell fresh or to greenhouses to be dried see figure (2.3).

Figure (2. 3): Thyme drying greenhouses.

Removing thyme leaves out of stem process is usually done in three stages. First, drying thyme plant by leaving it a couple of days in the greenhouse. Second, the process of splitting leaves out of the stem is done traditionally by hitting thyme stems with sticks until the leaves are removed from stems see figures (2.4) a and b. Third, the leaves are filtered in multi-stages filters so the crashed stems are removed from the leaves.

(a) Framer is removing leaves out of manually.

(b) Zoom view on the used tool. the stem

Figure (2. 4): Traditional Thyme splitting process.

Removing thyme leaves out of stem process faces a serious problem of how to remove the leaves without damaging the stem in order to have a pure leaves without any impurities .According to the traditional process, leaves with just 60% purity is achieved. Moreover, during the process the workers suffer from problems related to breathing issues produced from the way that thyme is hit which makes dusty surrounding environment. Other disadvantages of the traditional process that it’s a slow process which takes long working time to produce a little amount of thyme leaves. [2]

2. 4 Field and site visits

The team made field visit to wheat farming in order to find out how the harvesting and collection crop process are going on.

Wheat farmers in Ithnaa city are using mechanical machines consist of many mechanical mechanisms driven by drive shaft with timing belt to regulate the process. The machine harvest and collect wheat. Many mechanism are used to achieve the process, cutting blades are cuts wheat, then another mechanism used to collect wheat and prepare it for tying as illustrated in figure (2.5)

Figure (2. 5): Wheat harvesting machine.

Tying mechanism could be used in Thyme harvesting machine with some modification to be more suitable for our machine by driving the main parts of the mechanism by motors instead of gears with timing belt.

The tying mechanism is related to GEAR HOUSING FOR TIER ASSEMBLY OF BALER Filed patented. [3]

The team also made a site visit to the weaving factory in Hebron city which use the same patent in another form to tie two ropes two together. The machine is not appropriate to tying Thyme stacks because it depends on the idea of tying two separated ropes.

CHAPTER THREE

Conceptual Design for Thyme Harvesting and Thyme Splitting Processes

3.2 Introduction

3.2 Functional specifications

3.3 Generate designs and select solution

3.3.1 Thyme Harvesting Machine

3.3.2 Thyme Splitting Machine

3.4 The selected designs

3.1 Introduction

This chapter will demonstrate how to design the machines, and how to generate solutions for the requirements in many stages. The first stage is defining the requirements which should be achieved in the design, then generate suggested solutions for each requirement.

The second stage will be choosing the appropriate solution **according to the experiments and analysis done for several suggested solutions,** and many consideration, such as: the nature of thyme cultivation, thyme plant, space limitation and cost reduction.

The team will make a design to the first machine which is the harvesting machine, without building it. The second machine which is the splitting machine will be design and we will build it.

3.3 Functional specifications

According to economic and commercial issues beside the space limitation and safety and so many other specifications, it must be an alternative automated way to harvest and split thyme instead of traditional ways, this alternatives have to take into account many important basics, such as:

1- Thyme harvesting should be compatible with land shape and stems heights, since there are variations in heights of thyme's track. Some of tracks have a shape of arc so the harvesting altitude should vary according to the maximum height of land. Two type of thyme stem should be harvested each is different in height and in the stem diameter.

2- Separate Thyme leaves from stems without damaging them.

I. Thyme Harvesting Machine

1- Machine dimensions :
- 120 cm width.
- 100 cm length.
- 50 cm height.

These dimensions are determined according to the dimensions of thyme track as illustrated in figure (3.1).

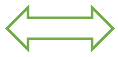


Figure (3.1): Thyme track.

2- Height of cutter blades from ground is between 5cm and 25cm according to ground shape and height.
3- Length of the blades is 110 cm in order to cut all thyme track width by one stroke.
4- The speed of the blades movement should be suitable to cut all types of thyme either local type or hybrid. See figure (3.2).

A: local type B: Hybrid type

Figure (3.2): Thyme types.

5- The speed of the machine is 5 Km/h to make sure that all thyme are processed and for safety issues.
6- The machine is pushed by tractor.
7- Stems are collected as stacks and tied by thread, using tying machine.
8- Body cover should be suitable for user safety.
9- DC power is used to generate the system.
10- Arduino microcontroller is used to control the machine operation.
11- Stakes diameter is between 5 cm and 10 cm.
12- Machine weight is less than 100 Kg.

II. Thyme Splitting Machine

1- Machine dimensions are:

- 230 cm length.
- 70 cm width.
- 135 cm height.

2- 220 V, 3 phase, AC electrical power is used to run motors and driving systems.
3- The needed productivity will be approximately 240 Kg per hour.
4- Process done without damaging stems.
5- Pure leaves are collected into a container and stems go out of the machine from its end.
6- Safety is taken by consideration.
7- The system can be run automatically or manual for maintenance needs, and to facilitate using the machine.
8- The machine will be easily used by worker.
9- PLC will be used to control the operation of the machine.
10- The machine will be able to move from place to another easily.
11- The machine input is a dry thyme.

3.4 Generate designs and select solution

According to the functional specifications mentioned in the previous section, the way of suggesting solutions is by taking each specification and generate designs to achieve it, then comparing between these designs to choose the best one. Obtained design will be shown in the next section (section 3.4).

These specifications are divided into two main categories for the two machines:

3.3.1 Thyme Harvesting Machine:

Specifications related to thyme harvesting machine:

❖ **Adjusting inclined thyme stems:**

Suggested solutions:

1) Triangular prism:

This part will be fixed at the two front sides of the machine as illustrated in the figure (3.3) it consists of two parts, first one is triangular prism and the other is cuboid. As the machine move forward the triangular prism slides under the inclined stems, this make the stems move with inclined track along the upper face of triangular prism. After that stems will reach cuboids part which is higher than the first part, this ensure that all stems with different heights are raised vertically to prepare it for cutting.

❖

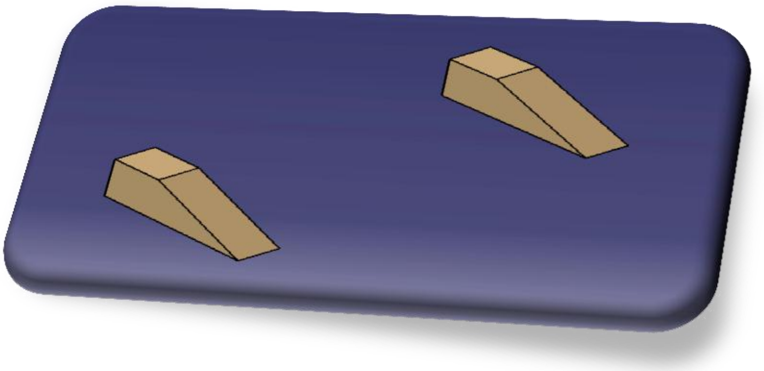


Figure (3.3): Triangular prism.

2) Twisted plate:

A twisted iron plate is fixed at the front of machine body. This plate is twisted from horizontal to vertical position, see figure (3.4). The horizontal side will slide under inclined stems, as the machine move, the stems move along the slope of twisted plate; this makes stems in vertical position at the end of the plate.

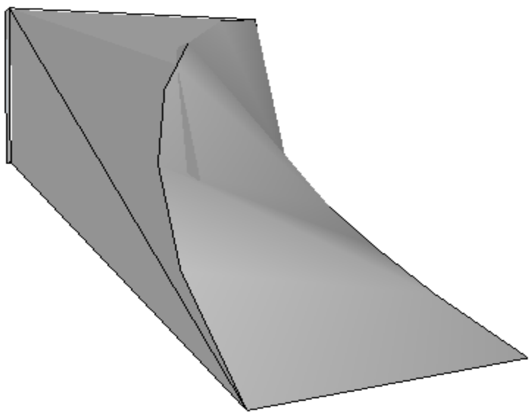


Figure (3.4): Twisted plate.

<u>Select solution:</u>

To adjust inclined stems we choose to put triangular prism since it dose the required function, and while the machine moves it doesn't carry soil and stones, and adjust inclined stems smoothly. On the other hand, twisted plate has many disadvantages, such as carry stones and soil during motion; if it hit a rock it will deform, and it will take off the plants from the roots during motion.

❖ **Cutting Thyme:**

<u>Suggested solutions:</u>

1) Blades:

Two blades each has a collection of triangle teeth positioned one above and one below as in figure (3.5), they move in the opposite direction of each other to cut the stems. Whilethe machine move, thyme stems come in between the teeth of the upper and below blades, which make the stems cut.

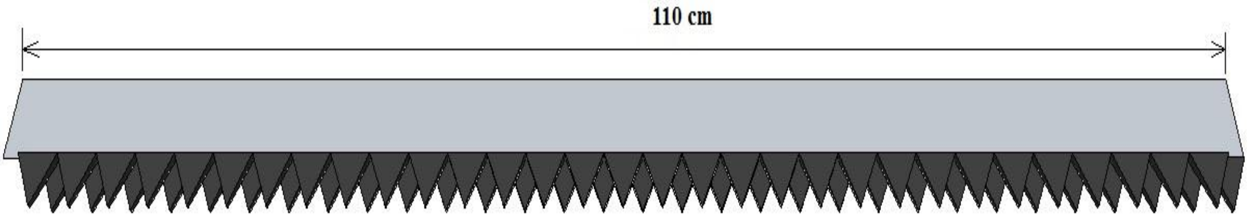


Figure (3.5): Zoom view on Blades.

2) Cylindrical blades:

A group of blades arranged in cylindrical form, see figure (3.6). While the machine moves the cylinder will rotate to cut the stems, the axis of rotation is the axis of cylinder.

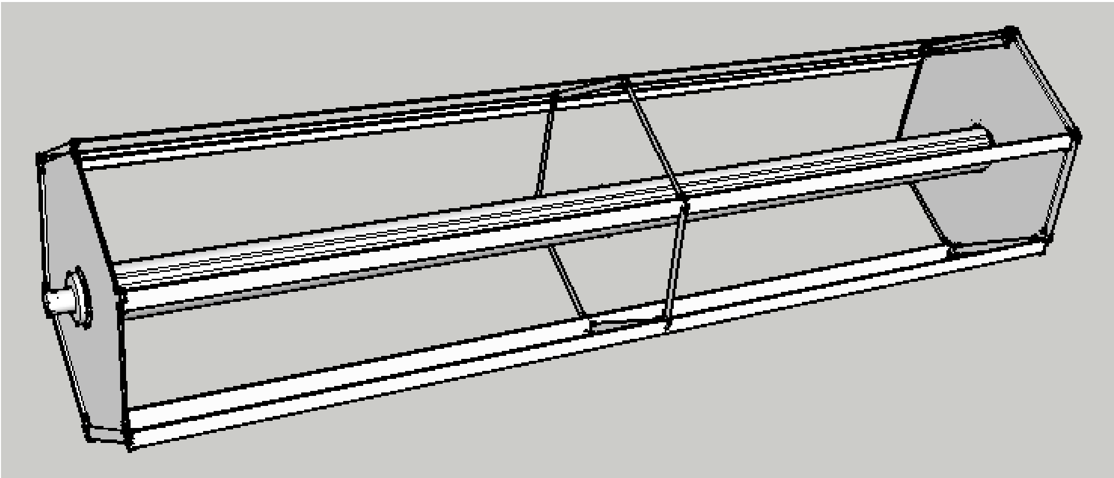


Figure (3.6): Cylindrical blades.

3) Rotating blades:

It's also a group of blades but arranged in circular form as illustrated in figure (3.7). The blades rotate around the axis shown, and with the movement of the, machine the stems will be severed.

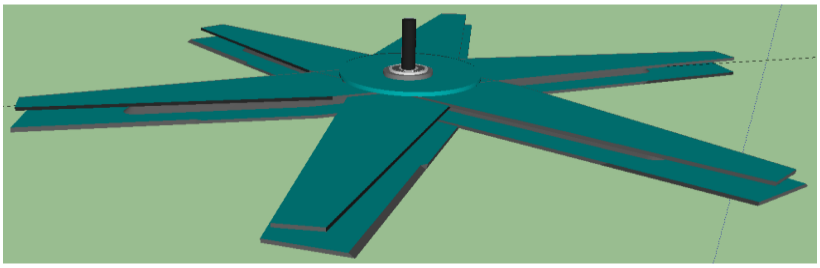


Figure (3.7): Rotating blades.

Select solution:

Cutting mechanism will be blades in the form of plates since they are more suitable for collecting stems; the other two types which are (rotating blades and cylindrical blades) are making it very hard to collect stems, and they are damaging the stems while cutting.

- **Thyme collecting:**

Suggested solutions:

1) Collecting arches:

They are arms with the shape of arches, the arms rotates to collect cut stems and direct them to the tying machine.

2) Conveyors with hocks:

Two conveyors with hocks, are fixed behind the blades. After cutting the stems, the hocks which are fixed to the conveyors catch the stems, the conveyor rotates to direct the stems into a track which exist at the middle of the machine, and this track directs stems into tying mechanism. To prevent full rotation of stems, two rods will be added to the system as shown in the figure (3.8), when the stems reached the middle, the rods will direct them into the track.

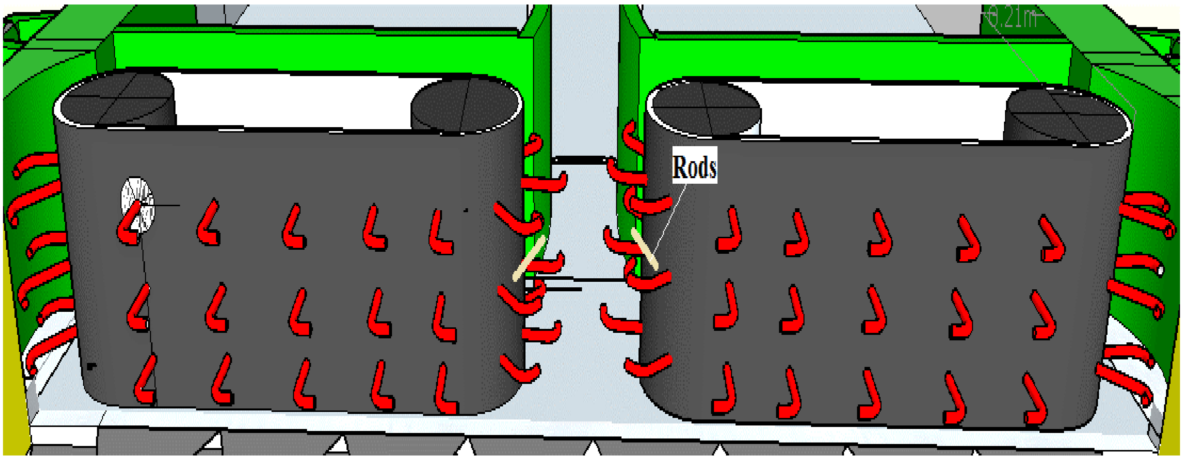


Figure (3.8): Conveyors with hocks.

Select solution:

Conveyor with hocks will be used to collect stems after cutting them; it has many advantages, smooth motion in collecting stems, can collect stems with variation in heights, and collect maximum possible amount of stems. On the other hand, assembly arches spread stems in all directions so it cannot collect all cut thyme, it's not capable to collect short thyme stems.

- **Tying mechanism:**

Suggested solutions:

1) Thermal welding of threads:
Process involves connecting the two ends of thread by heat welding. A needle catches one end of the thread and a tong (ملقط) catches the other end, the needle turn around a group of stems to reach the tong, at this stage the tong catches the two ends and then heated the two ends to melt and cleave them at each other.

2) Sewing thread.

3) Adhesive to connect the two ends:
Similar to the first solution, but instead of using heat welding, an additional roll of adhesive used to feed the mechanism of adhesive, at the stage when the tong catches the two ends.

4) Tying mechanism used for weaving industry.

5) Rubber band. As in figure (3.9) used to collect Thyme stems.

Figure (3.9): Rubber band.

6) Cable ties shown in figure (3.10) used to collect Thyme stems.

Figure (3.10): Cable ties.

Select solution:

In order to choose the better tying mechanism, the following specifications should be taken in consideration:

- Operating cost.
- Space limitation.

- Easy maintenance.
- Environmentally friendly.
- Safety.

According to these specifications we choose tying mechanism which is similar to tying mechanism used in wheat harvester. The other choices such as adhesive, cable ties, sewing thread, and rubber band have high production cost. Some of alternatives are not safe to implement, such as thermal welding

❖ **Machine rising mechanism:**

Suggested solutions:

1) Screw jack mechanism:

Used to overcome a heavy pressure or raise a heavy weight by a much smaller force applied at the input driver. It is operated by turning a lead screw which makes pull or push force at the body.

The jack can be raised and lowered with a metal bar that is inserted into the jack. A motor applies a clockwise rotational motion which turns the screw inside the jack and drive it upward. The screw lifts the small metal cylinder and platform that are above it. As the jack goes up, whatever is placed above it will raise as well. The bar is turned until the jack is raised to the level needed. To lower the jack the bar is turned in the opposite direction. See figure (3.11).Two jacks at the both side of the harvester machine will be used.

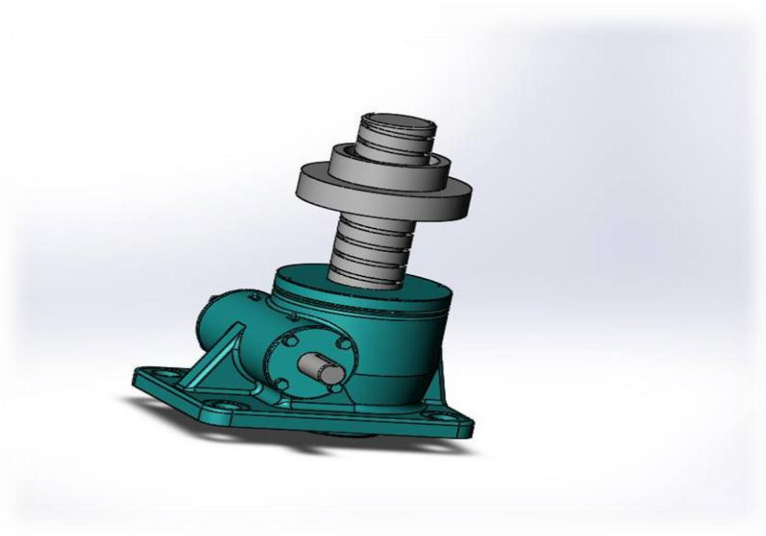


Figure (3.11): Screw jack mechanism.

2) Hydraulic system to control the altitude of machine:

Two pistons could be fixed at the both side of the harvesting machine used to rise and down the machines. Hydraulic systems usually used to carry heavy loads while the harvesting machine is light to use such a system. Beside the system needs too much component to operate like the hydraulic pump, oil tank, oil filter, and so many other components so it will be difficult to use such a system due to space limitation and the high cost, maintenance.

Select solution:

Screw jacks will be used to rise and down the machine instead of hydraulic pistons, since the motor in screw jack easier to control than hydraulic system. Hydraulic system needs a lot of components which makes it economically unsuitable, moreover, hydraulic systems used in applications needed high forces.

3.3.2 Thyme Splitting Machine:

Specifications related to thyme splitting machine:

❖ **Receiving stacks from worker:**

Suggested solutions:

1) Lift conveyor:

It's a conveyor used to transfer stacks from the worker to the next stage. The conveyor consist of barriers with the shape of triangle, each barrier carry one stack, the stack putted inversely, then the conveyor move from down to up with angle, at the top of the conveyor the stacks will be delivered to the next stage. See figure (3.12).

Figure (3.12): Lift conveyor.

2) Hanging conveyor:

It’s a horizontal conveyor that contains a group of curved hocks, as illustrated in figure (3.13). Each stack hanged on one hock, and as the conveyor rotate, the stacks will be delivered to the next stage at the end of the conveyor.

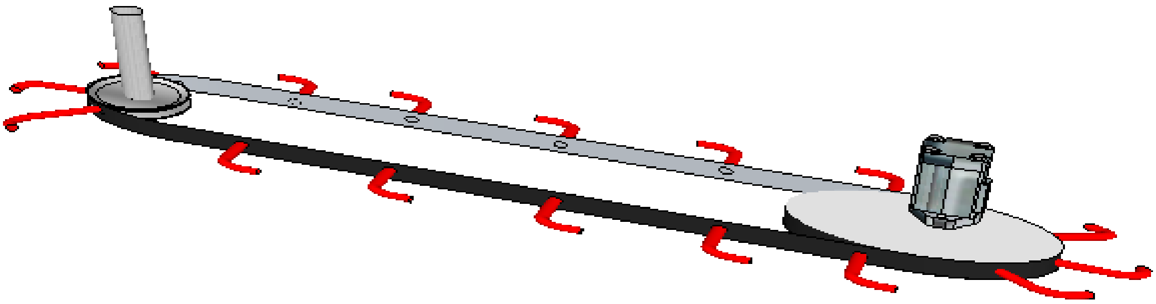
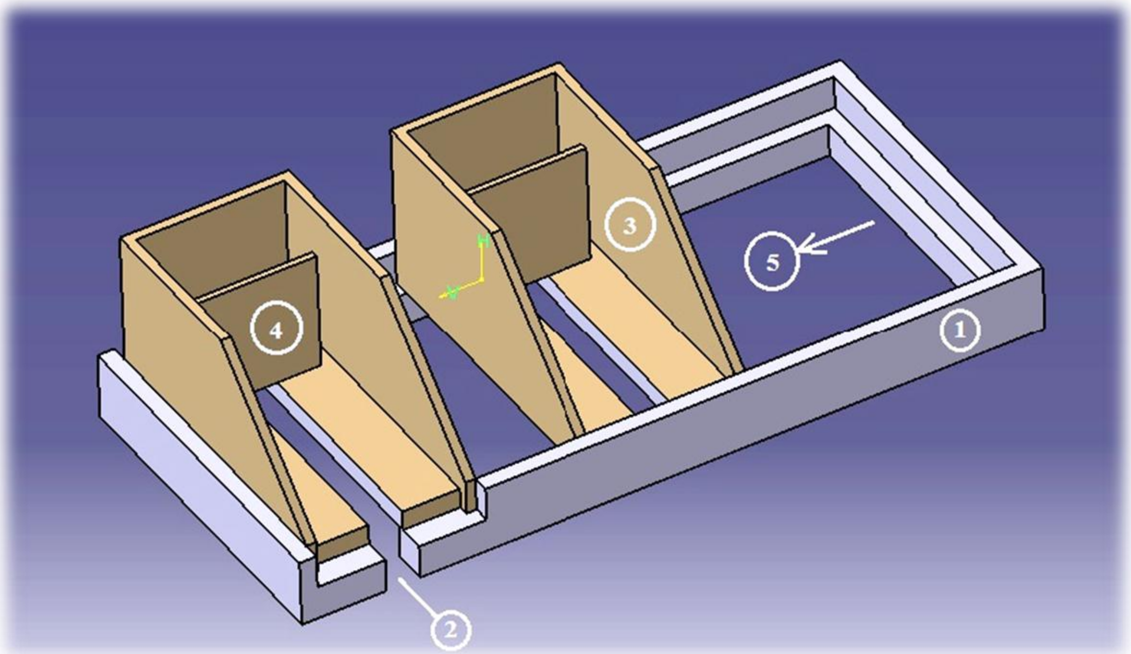


Figure (3.13): Hanging conveyor.

3) Boxes with groove:

Boxes with groove placed at special base, as illustrated in figure (3.14). The stacks hanged in the groove of each box as series, then the plate with spring will push the stacks into V-belt, as the first box is empty the worker remove it from the behind and another full box come instead of it by spring force.



A: Front view.

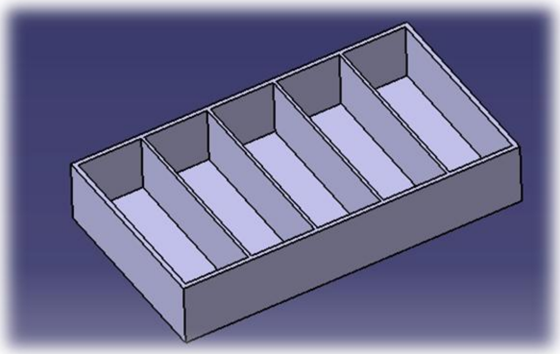
B: Back view.

Figure (3.14): Boxes with groove.

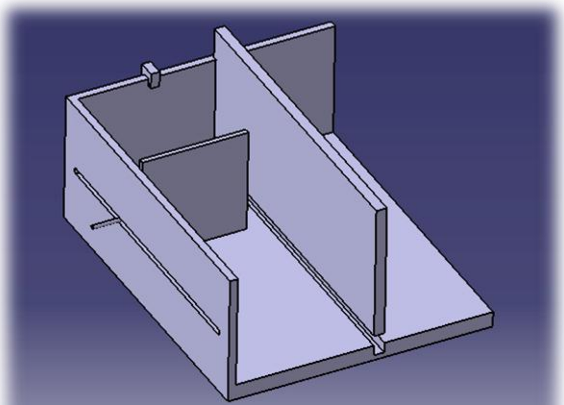
1) Base of boxes.
2) Exit of stacks to V-belt.
3) Box.
4) Plate with spring force to push stacks into V-belt.
5) Spring force to replace empty box with full stacks box.
6) Worker remove empty boxes.

4) Multi zones box:

Box with multi zones, each zone consist of series of stacks, other part is fixed behind the V-belt to receive stacks from box and deliver it to the V-belt. The worker push the stacks from the first zone to the fixed part. As the first series of stacks pulled be V-belt, the worker pulled the next series of stacks to the fixed part, and so on. See figure (3.15).



A: Multi zones box.



B: Fixed part

Figure (3.15): Multi zone box parts.

<u>Select solution:</u>

Lift conveyor is more suitable than the other suggested solutions in this operation. Lift conveyor is better in delivering stacks into the next stage, its smoother, safer, and doesn’t damage stems.

- **Cutting the thread:**

<u>Suggested solutions:</u>

1) Thermal blade with pneumatic actuating:

This blade consist of electrical resistance. As the mechanism turned on, a current passes through the resistance, the current will rise the temperature of the resistor in order to use it to cut the plastic robe. A pneumatic piston used to push the blade when the stack reached a specific position. A limit sensor used to detect that the stack is at the suitable position.

2) Fixed blade:

A blade fixed at specific position where the thread pass used to cut the robe.

<u>Select solution:</u>

In order to cut the thread we choose to use fixed, this system is less in cost and power consumption, and its do the specific goal.

- **Stems separated to move:**

<u>Suggested solutions:</u>

1) Multi-speed conveyors:

This mechanism consist of many vertical conveyors, each conveyor move with different speed, the stacks will put on the first conveyor perpendicular to the direction of motion, this conveyor moves with slow speed, the stacks are delivered to the next conveyor which move faster, and then to the next conveyor with the same procedure until the stacks be stem by stem.

2) V-Belts conveyor:

Two horizontal belts fixed closed to each other, at the beginning the two belts are far from each other and then they become closer to each other until they slightly touch each other, see figure (3.16). As the belts rotate with the opposite direction of each other and the same speed, the belts catch the entire stack, and with the reducing of the distance between the two belts the stack become stem by stem closed to each other. This mechanism produces suspended stems ready for splitting. This system catches the stems from the first 1.5cm and the rest of stem is suspended.

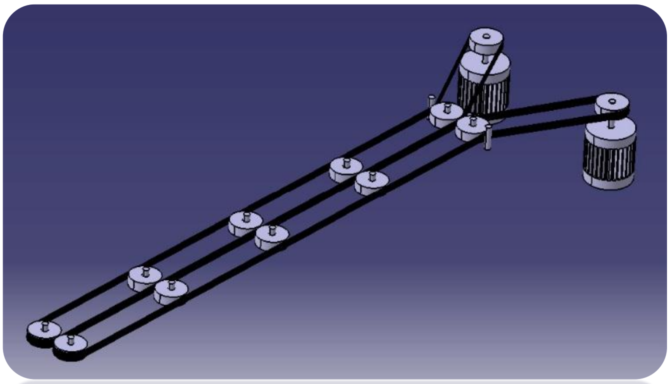


Figure (3.16): V-Belt conveyor.

<u>Select solution:</u>

V-Belt Conveyor will be used instead of Multi-Speed Conveyors. According to the size needed V-Belt Conveyor needs smaller space than the space needed in Multi-Speed Conveyors, also the first system ensure less damaging in stems than the other. The output of the V-Belt is stems suspended vertically which is considered more suitable to split thyme than the output of Multi-Speed conveyors.

❖ **Separating leaves out of stems:**

<u>Suggested solutions:</u>

1) Two horizontal cylindrical brushes:

Stems fall between two cylindrical brushes, the brushes rotating with opposite direction which make the leaves separated from stems.

2) Rotating brushes groups:

This system consist of two groups each group contains three brushes. Each group rotate in the same direction, and the other three brushes rotate in the opposite direction. The brushes will split the thyme leaves from the stem when the stems move between the two groups. See figure (3.17).

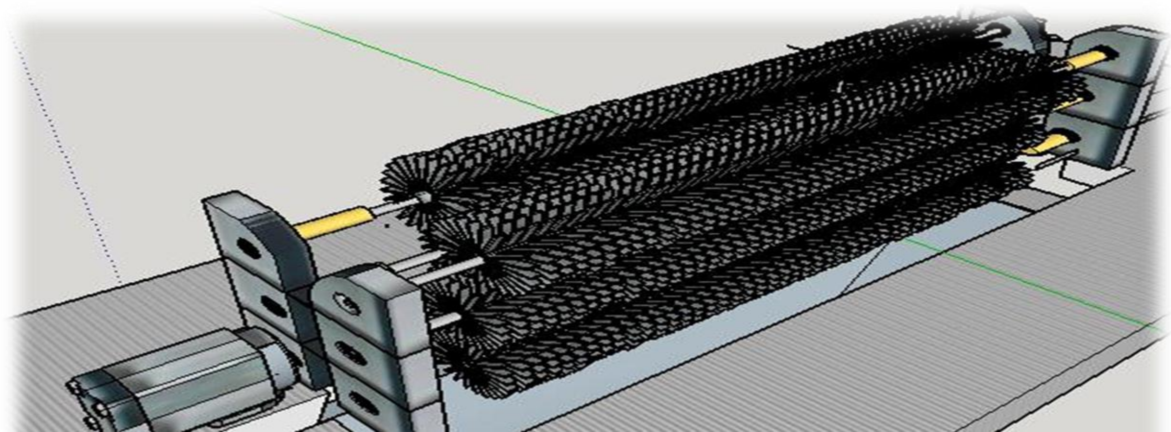


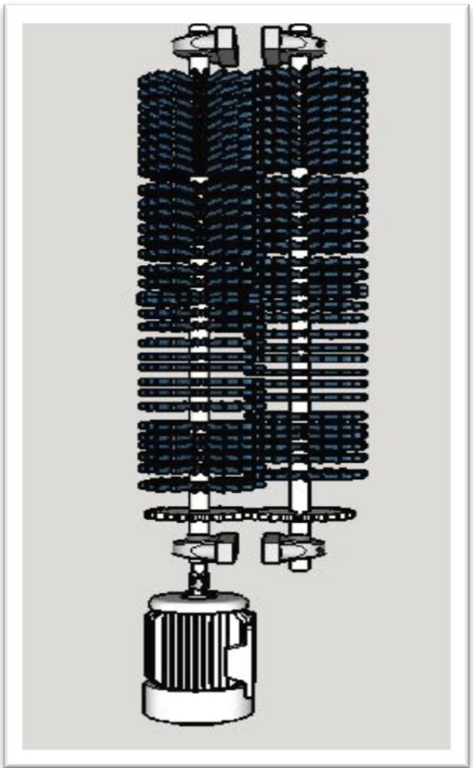
Figure (3.17): Rotating brushes groups.

The stems putted between two horizontal plates of metal, each plate moves in reciprocal way in the opposite direction of each other, this motion with the brushes fixed on plate make the leaves separated from branches.

3) Two stages of brushes:

Two stages of brushes will be used, the first stage consist of vertical brushes, which can be useful to separate stacks to stems, at the same time vertical brushes split these stems.

The next stage is inclined brushes, while the stems pass through the brushes the leaves will be pulled down, see figure (3.18), this may be useful to split stems, that’s why they are inclined. In the other hand, this method will decrease the required brushes comparing with (group of brushes) mentioned in previous point.



A: Vertical Brushes.

B: Inclined brushes.

Figure (3.18): Two stage of brushes.

Select solution:

According to the experiments done at the three suggested solutions, two stages of brushes will be used, vertical brushes and then inclined two brushes is the best choice compared with the other two suggested solutions, because less number of brushes needed. Moreover, two stages of brushes gives splatted leaves with 90%, the two other solutions was with less percentage. The last reason for choosing inclined brushes is minimum damaging in stems achieved by this method.

- **Collecting pure leaves:**

A container placed under the brushes is used to collect the leaves falling.

3.4 The selected designs

According to the previous discussion and analysis, the designs selected for both machines will be as the following:

A) Thyme Harvester Machine:

Harvester machine cuts thyme plants from farm tracks by first rising the inclined plants, then forcing the middle and side plants to move along tracks using barriers. After that, the blades cut the stems. A vertical conveyors with hocks are used as jointing mechanism which collect thyme stems to specific track, to direct them into tying mechanism which wraps a thread around a collection of stems to be stacks. Tied stack come out of machine due to pushing of the next stack.

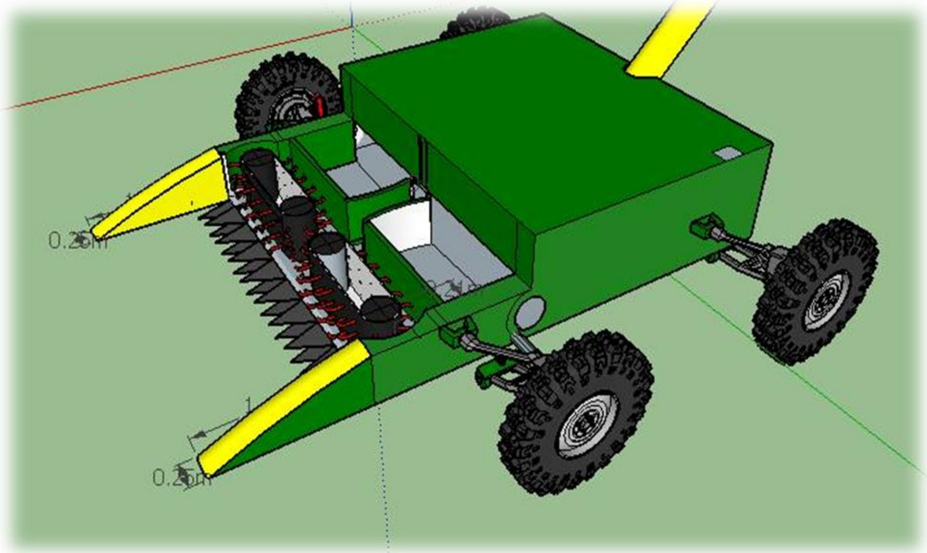


Figure (3.19):Thyme Harvester Machine.

B) Thyme Splitting Machine:

After transporting the thyme stacks to dry them, the next stage is removing leaves out of the stem process (split thyme). Splitting process starts when a worker supply conveyor with thyme stacks as the conveyor is responsible of delivering thyme stacks to the Splitting Machine. The moment when the thyme stacks are delivered from the lift conveyor to Splitting Machine, the thread of the stacks will be cut using thermal blade. Then, two horizontal belt conveyor(V-Belt Conveyor) will catch the stacks in a vertical position and pull it along an enough distance, and two fins at both sides ensure that the stacks is distributed and become a net stacks closed to each other and ready to separate leaves from stems. After that a couple of brush-groups installed horizontally at the two sides of stems rotate to separate leaves from stem, each brush-group is rotating in the opposite to the other group .

Leaves will be left out of the stem to fall vertically by means of gravity and an associated air flow to enter a container which used to collect leaves, leaves-free stems will continue coming out of the machine into another container.

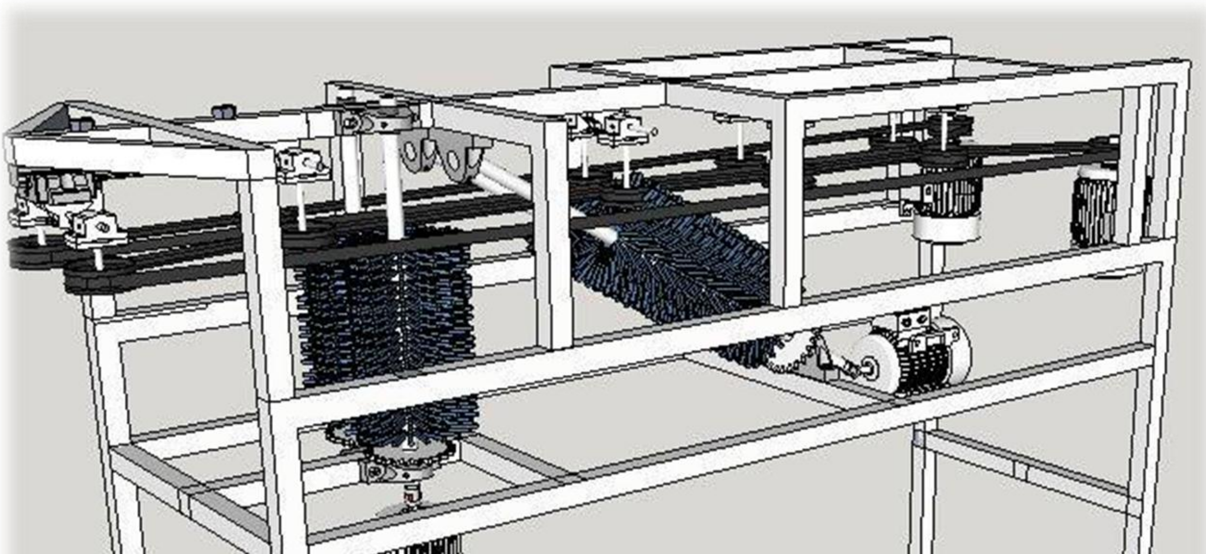


Figure (3.20):Thyme Splitting Machine.

CHAPTER FOUR

Mechanical calculations

4.3.1 V-belt conveyor

4.3.2 Lift conveyor

4.3.3 Brushes

Table (4.1): Symbols Table

Symbol	Description	Symbol	Description
S_y	yield strength	V_h	Speed of harvester
N	factor of safety	d_p	Diameter of conveyer pulleys
σ_c	compressive stress	V_c	Speed of conveyer motor
σ_t	shear stress	F	force required to rotate belt
p	thread pitch	r	radius of pulley
d_r	minor diameter	Fr1	friction force at upper driver
d_m	mean diameter	Fr2	friction force at lower driver
d_c	major diameter	μr	coefficient of friction
W	load	mB	mass of belt
P	power	ma	mass at the drive drum

T	torque	m	total mass of load conveyed
N	velocity (rpm)		
Ω	velocity (rad/s)		
μ	coefficient of friction		
A	helix angle		
L_h	length of hocks		
P	Thyme density per area		
L_c	width of conveyer		

4.1 Introduction

This chapter demonstrate how to determine the suitable motors required to run the systems, such as: screw jack, conveyor with hocks, V-belt conveyor, lift conveyor, and brushes.

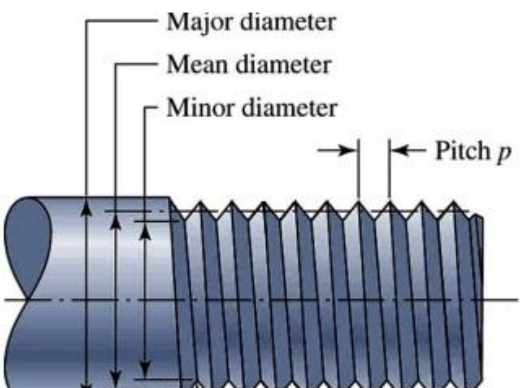
Some of design requirements founded in experiments, and the other will be calculated.

4.2 Thyme harvesting machine

4.2.1 Screw jack

It is required to design a screw jack to lift the front parts of harvesting machine in order to be suitable to the variation of land shapes. The screw jack should lift a mass of 100Kg with a maximum lifting height of 20cm.

Hot-Rolled AISI 1015 steel is selected as the material for the screw. It is cheap and it can be given any complex shape without involving costly machining operations. It has yield strength of 190 MPa. Taking a very high factor of safety of 3 due to the nature of the application.



$\sigma_c = \frac{S_y}{N} = \frac{190}{3} = 63.3$ MPa …………………..1

Minor diameter (d_r):

$d_r = \sqrt{\frac{W}{\frac{\pi}{4}\sigma_c}} = \sqrt{\frac{981}{\frac{\pi}{4} x\ 63.3\ x\ 10^6}}$ = 4.44 mm = 0.17 inch.…..2 Figure (4.1): Screw jack.

According to the Standard ACME Thread Dimensions as shown in the table below:

Table (4.2): Standard ACME thread dimensions.

Standard ACME Thread Dimensions

Major diameter (in)	Threads per inch	Thread pitch (in)	Pitch diameter (in)	Minor diameter (in)	Tensile stress area (in^2)
0.25	16	0.063	0.219	0.188	0.032
0.313	14	0.071	0.277	0.241	0.053
0.375	12	0.083	0.333	0.292	0.077
0.438	12	0.083	0.396	0.354	0.110
0.500	10	0.100	0.450	0.400	0.142
0.625	8	0.125	0.563	0.500	0.222
0.750	6	0.167	0.667	0.583	0.307
0.875	6	0.167	0.792	0.708	0.442
1.000	5	0.200	0.900	0.800	0.568
1.125	5	0.200	1.025	0.925	0.747
1.250	5	0.200	1.150	1.050	0.950
1.375	4	0.250	1.250	1.125	1.108
1.500	4	0.250	1.375	1.250	1.353
1.750	4	0.250	1.625	1.500	1.918
2.000	4	0.250	1.875	1.750	2.580
2.250	3	0.333	2.083	1.917	3.142
2.500	3	0.333	2.333	2.167	3.976
2.750	3	0.333	2.583	2.417	4.909
3.000	2	0.500	2.750	2.500	5.412
3.500	2	0.500	3.250	3.000	7.670
4.000	2	0.500	3.750	3.500	10.321
4.500	2	0.500	4.250	4.000	13.364
5.000	2	0.500	4.750	4.500	16.800

According to the table, we choose minor diameter to be:

d_r= 0.188 inch = 4.77 mm.

Thread pitch (p) = 1.6 mm.

Mean diameter (d_m) = 5.56 mm.

Major diameter (d_c) = 6.35 mm.

Since the length of screw is 20 cm, the number of threads (n), is:

No of threads per inch =16 thread………………………………………………………...3

20 cm = 7.87 inch

N = 7.87x16 = 126 threads……………………………………………………………4

The helix angle of screw:

tanα = $\frac{P}{\pi\ d_m}$ = 0.0916………………………………………………………………5

α= 5.235°

coefficient of friction for this material is:

μ = 2.3

μ = tanβ = 2.3

β = 66.5°

The turning moment required to rotate screw under design load is given by T = W (dm/2) tan (α+β) = 8260.7 N.mm = 8.2607N.m…………………………………………………...6

Since the machine has to reach the maximum height in 30 seconds, it has to raise 126 thread "revolution" in 30 seconds:

n = 126*(30/60)

=63 rpm

ω = 6.59 rad/s

P = T ω = 8.2607 x 6.59 = 54. 4 watt. ……………………………………………………………7

4.2.2 Conveyor with hocks

It is required to design a Conveyors with hocks to direct the stems into a track which exist at the middle of the machine and this track directs stems into tying mechanism. The conveyor has to transport the stems of density 0.5 kg/1m^2 and capacity of 2.5tons/hour.

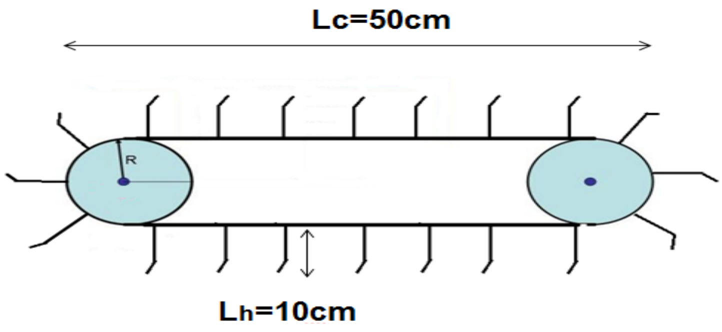


Figure (4.2): Conveyor with hocks.

L_h:length of hocks =10 cm “Choose this length to catch twigs without dropping"

ρ=0.5Kg/m^{2}distribution of thyme per area

L_c: width of conveyer

$V_{h:}$ Speed of harvester =5km/h

$$V_h = \frac{5000}{60 \times 60} = 1.4m/s \ldots\ldots 1$$

The speed of conveyer:

The conveyer moves for 50cm distance at the same time of 10cm moving of harvester

Sample:

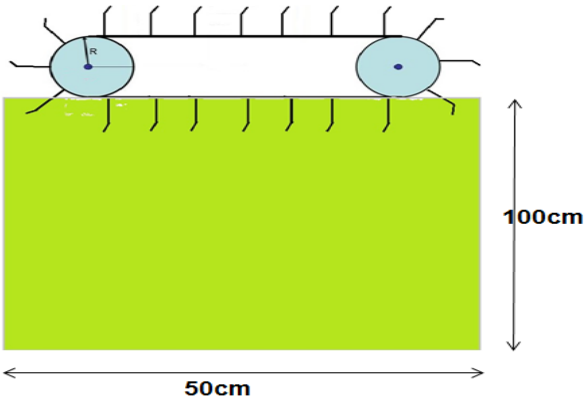


Figure (4.3): Distribution of thyme in front of machine.

$$\frac{L_h}{V_h} = \frac{L_c}{V_c} \ldots\ldots 2$$

$$\frac{10cm}{\frac{1.4m}{s}} = \frac{50cm}{V_c}$$

$$V_c = 1.4 \times 5 = 7\, m/s \ldots\ldots 3$$

Diameter of the conveyer pulleys is $d_p = 10cm$

Speed of conveyer motor $V_c = \omega \times r_p \, , r_p = {}^{d_p}/_2 = 5cm = 0.05m$

$$7 = \omega \times 0.05 \ldots\ldots 4$$

$$\omega = 140\, rad/s$$

$$n = 140 \times \frac{60}{2\pi} \approx 1337rpm \ldots\ldots 5$$

Required speed of motor =1337 rpm

Conveyor Load

Belt dimensions:

$area = (L_C \times d \times 2) + (2 \times \pi \times R)m^2$……………………………………………………6

$$area = (0.5 \times 0.5 \times 2) + 2 \times (2 \times 3.14 \times .05)m^2$$

Area of belt=1.1281m^2

RubberDensity =1522kg/m^3

Thickness =3mm

$m = v \times \rho$…………………………………………………………………………………7

$$m = 0.814 \times 0.003 \times 1522 = 3.72kg$$

W_b=3.72× 9.81=36.5N……………………………………………………………………..8

Hocks

Number of hocks 40

w= n ×.m_h×9.81………………………………………………………………………….9

$$w = 40 \times .01 \times 9.81$$

W_h= 4N

Stems of Thyme

$m = A * \rho$………...…………………………………………………………………10

m_s=0.5×0.1×0.5=25g

W_s=0.025×9.81=0.245N

F =W_s +W_h +W_b…………………………………………………………………………………………………… 11

F= 40.75

Torque

$T = FR$…………………………………………………………………………………12

$$T = 40.75 \times 0.05$$

$$T = 2.04N.m$$

$P = T * w$……………………………………………………………………………13

$$P = 2.04 \times 140 = 285w$$

P=0.375hp

4.3 Thyme splitting machine

4.3.1 V-belt conveyor

According to spring gauge experiment the force required to rotate the belt is:

F = 580 N

So, the torque is:

T = F * r ……………………………………………………………………………1

T = 580 x 0.05 = 29 N.m

The angular velocity is:

n = 100 rpm

$\omega = 100\frac{2\pi}{60} = 10.46$ rad/s

P = ω * T = 10.46 x 29 = 303 watt = 0.4 hp…………………………………………..2

So, we choose to use 0.5 hp motor.

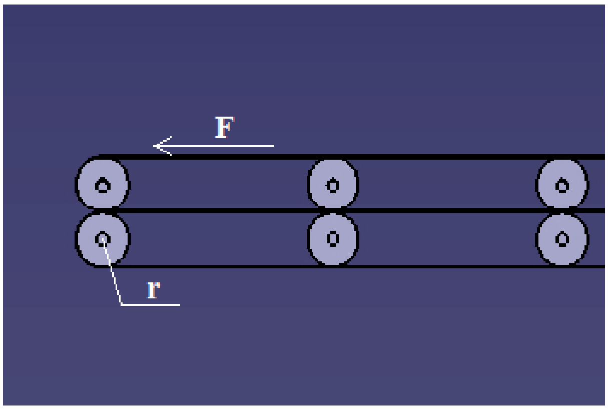


Figure (4.4): V-belt conveyor.

4.3.2 Lift conveyor

Σ F = m a……………………………………………………………………………1

F = Fr1+Fr2+ mg*sin (ვ) = 0

F = 2*μr (mB+ ma) *g*cos (ʒ) + mg*sin (ʒ) = 0

= 2*0.3(0.056+0.5)*9.81*cos (60) + 5*9.81*sin60

= 44.2 N

Fr1=Fr2 = μr (mB+ ma) *g*cos (ʒ)

T = F*r = 44.2*0.05 = 2.205 N. m…………2

Mechanical power:

P = ω *T/1000 = 100*2.205/1000 = 0.22 Kw….3

Where:

- Estimated belt angular velocity = 10 RPM

- Drive drum estimated diameter = 0.005 m

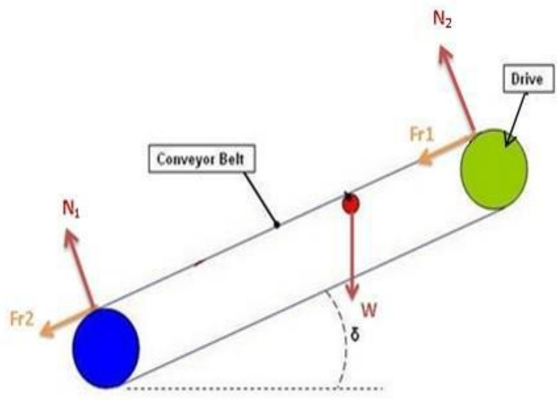


Figure (4.5): Lift conveyor.

4.3.3 Brushes

To find the torque required to rotate the brushes, a thread with mass tied to the gear of brushes as shown in the figure (4.6):

The mass required to rotate the brushes is measured to be:

m = 6 kg

So, w = mg……………………………..1

w = 6 x 9.81 = 58.86 N

Now, the torque is:

T = w r = 58.86 x 0.075 = 4.415N.m….2

Since the brushes will rotate at 200 rpm

ω= 21 rad/s

So, P = T ω= 92.7watt……………………3

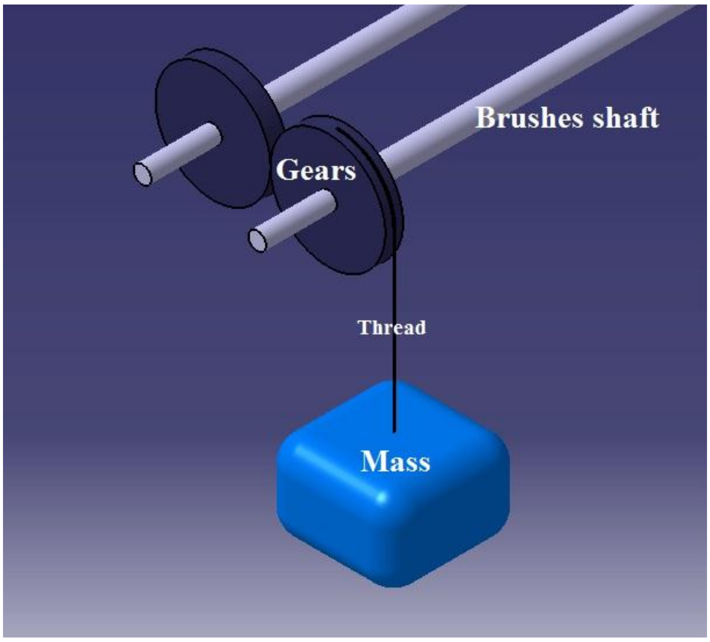


Figure (4.6): Brushes experiment.

Note: This experiment done while the line between two brushes filled by stacks of thyme.

CHAPTER FIVE

Mechanical Components

5.1 Introduction

This chapter will demonstrate the dimensions of mechanical parts and mechanisms in the project. Sketches will be used to support the analysis. Section 5.2 talks about the mechanical components for thyme splitting machine, and section 5.3 talks about mechanisms dimensions such as: V-belt, lift conveyor, brushes, and machine dimension.

5.2 Dimensions of components of thyme splitting machine:

- **<u>The V-belt contains three main parts:</u>**

1. Bearing

A bearing is machine element that constrains relative motion to only the desired motion and reduces friction between moving parts, and the design of the bearing that we used provide for free rotation around a fixed axis

Figure (5.1): Ball bearings.

Characteristics of the used ball bearings:

D1: inner diameter

D2: outer diameter

B: thickness

Table (5.1): Dimensions of the bearing.

	Inner diameter	Outer diameter	Thickness
Ball bearing	10 mm	30 mm	10 mm

2. Pulleys:

A pulley is a wheel on a shaft that is designed to support movement and changing of direction of belt along its circumference.

Figure (5.2): Pulleys.

Characteristics of the used Pulleys:

One groove pulley

A: outside diameter

B: bore diameter

C: Hub diameter

D: inner diameter

E: screw diameter

L: overall width

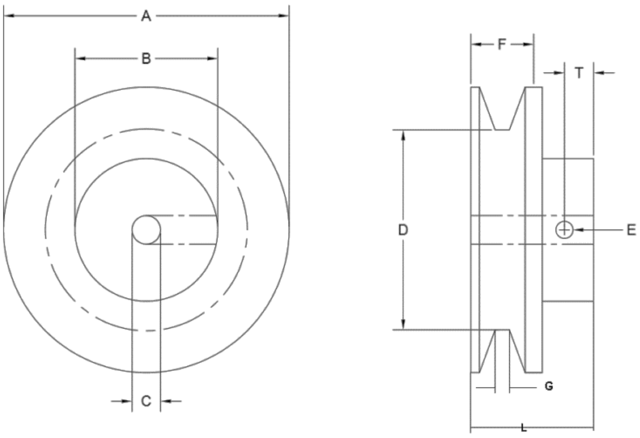


Figure (5.3): One groove pulley.

Table (5.2): Dimensions of the one groove pulley.

	A	B	C	D
Pulley	100mm	50mm	10mm	60mm
E	**F**	**G**	**L**	**T**
6 mm	22 mm	6 mm	40 mm	6mm

3. V-belts conveyor

A belt is a loop of flexible material used to mechanically link two or more rotating shafts.

The V-belt that we used in the machine is called raw edged belt and it’s a complete line of V-belts with iron sheaves (5VX 1800 belt).

Features:

1-Heat resistance.

2-Stable transmission with large capacity factor saving energy.

3-The shaft can be in any degree between 30c to 100c.

4-It can bears high tension over its cross section.

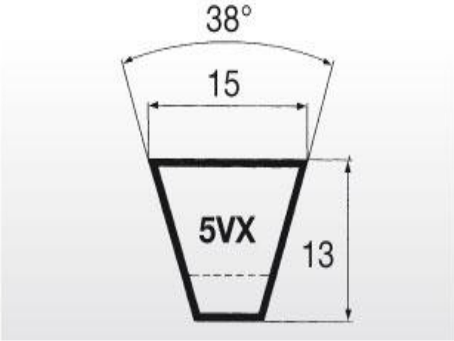


Figure (5.4): V-belt with dimensions

- **<u>Brushes</u>**

5) Helical Brushes:

The brushes that we used are made to separate the leaves from the stem of the thyme plant.

Figure (5.5): Brushes.

The shaft ball bearing to rotatearound its axis.

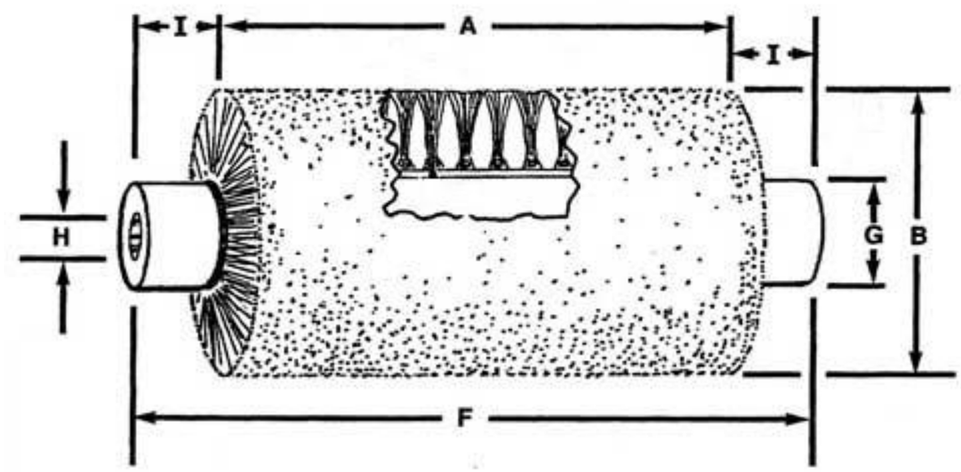


Figure (5.6): Dimensions of the brushes.

Table (5.3): Dimensions of the brushes.

A	B	F	G	H	I
90 cm	15 cm	110 cm	2 cm	0 cm	10 cm

A) Vertical block housing included bearing

The housings which have a bearing fitted into them and thus the user need not purchase the bearings separately, and we will use them with the helical brushes.

Fig (5.7): vertical block housing included bearing.

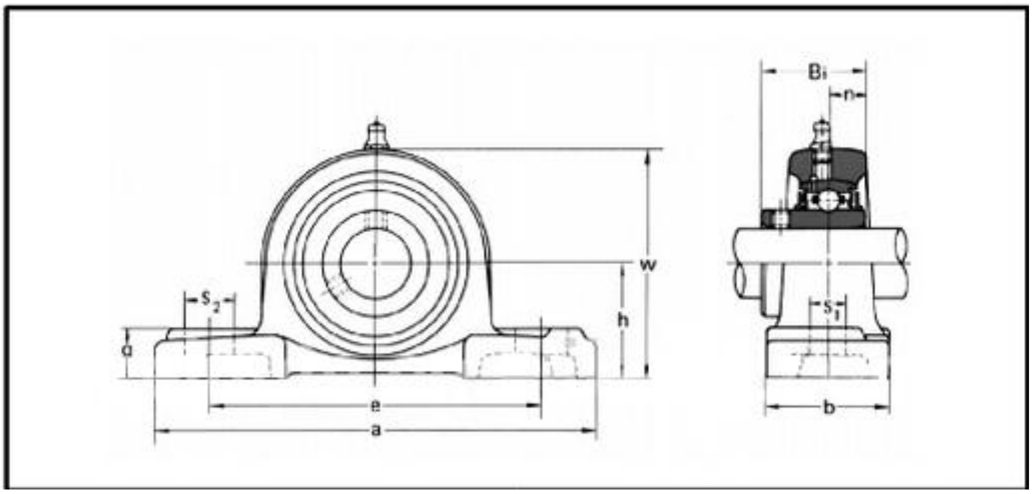


Fig (5.8): vertical block housing included bearing sketch.

Bearing No.	Size mm											Oil size mm
	Shaft Diameter	h	a	e	b	S1	S2	g	w	Bi	n	
UCP204	20	33.3	127	95	38	13	19	14	65	31	12.7	10

Table (5.4): dimensions of: vertical block housing included bearing.

B) Gears

We use the gear to reverse the direction of rotation between the brushes.

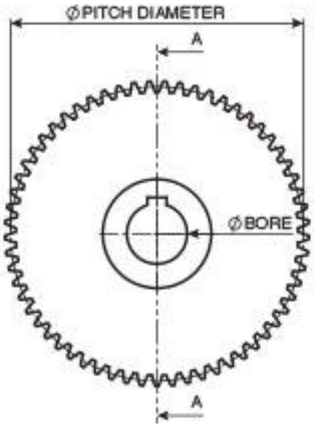


Fig (5.9): gear.

Table (5.5): dimensions of gear.

Pitch diameter	Bore diameter
14.7cm	2.0cm

❖ <u>Screws used in the project</u>

Two main types of screws will be used:

a) Hexagon blot :

The hexagon bolt is to join the main parts of the machine together temporarily to easy the maintenance.

DIN 933 steel 8.8 galvanized with various specifications.

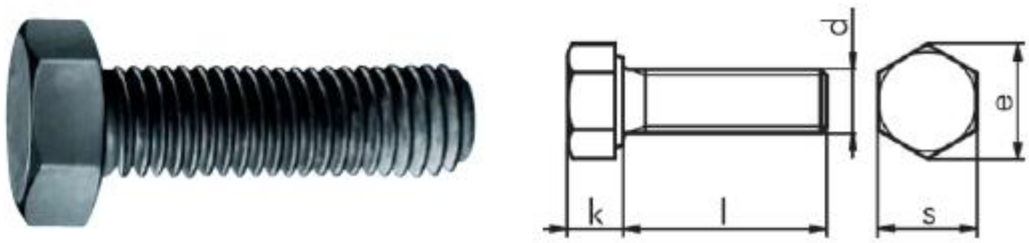


Figure (5.10): Screw with dimensions.

Table (5.6): dimensions of the screw.

	K	E	S

Hexagon bolt	5.3mm	14.38mm	14mm

b) Set Screw

ISO 4026 steel 45H plain the second is to join the pulleys with its centric shaft, with the following specifications.

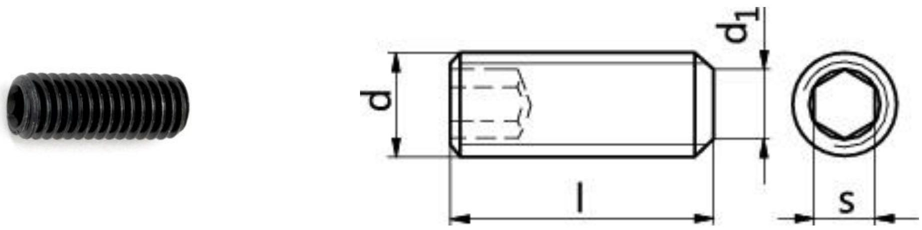


Figure (5.11): Set screw with dimension.

Table (5.7): Dimensions of set screw.

	D	d1	S	L
Set Screw	8 mm	5.5 mm	4 mm	20 mm

Washers

DIN 7980 galvanized steel, square bar steel.

We used the split lock washer because it works to absorb the vibration induced while the machine is working. With various diameters, thickness, and width corresponding to the Hexagon Bolt we used.

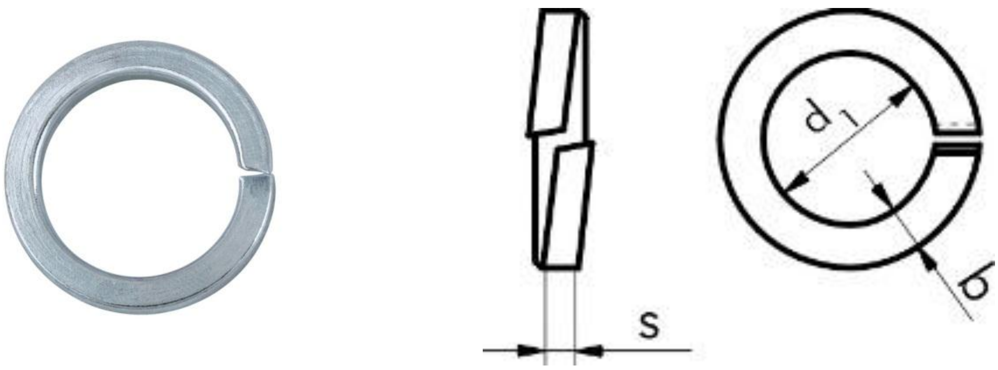


Figure (5.12): Washers.

Nut

DIN 934 steel I10I plain

With various dimensions depending on the screws

Figure (5.13): Nut.

5.3 Dimensions of mechanisms

5.3.1 Lift conveyor

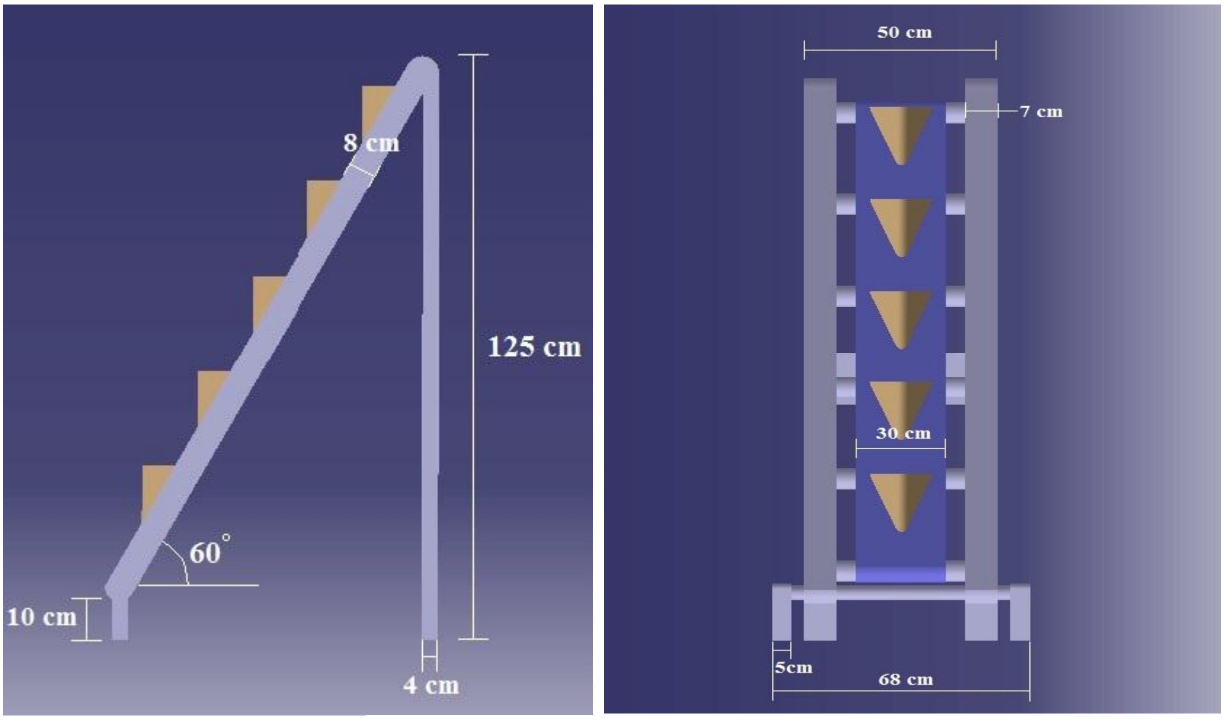


Figure (5.14): Lift conveyor dimensions.

Pocket dimensions:

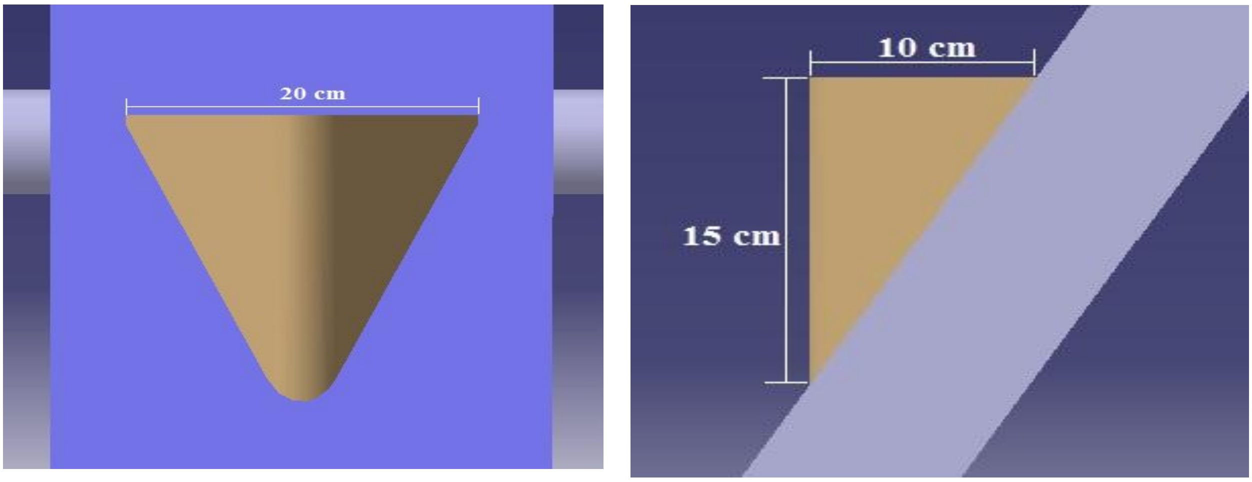


Figure (5.15): Pocket dimensions.

5.3.2 Brushes dimensions

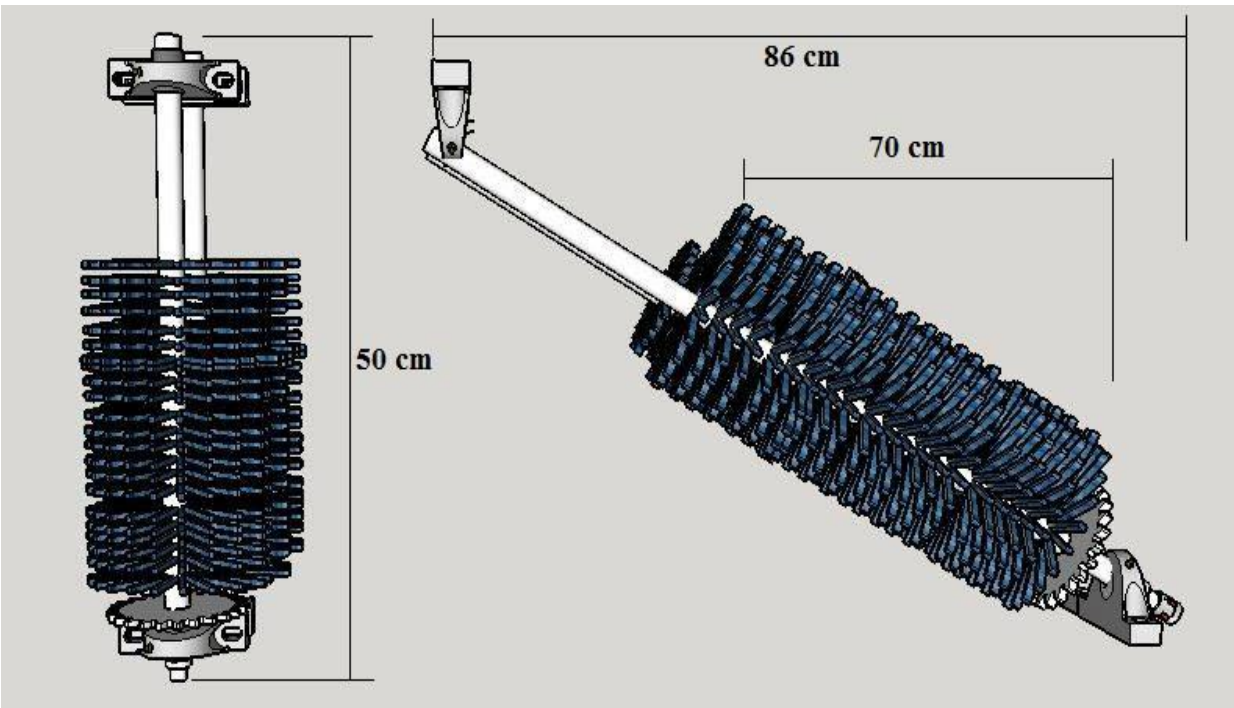


Figure (5.16): Brushes dimensions.

5.3.3 V-belt

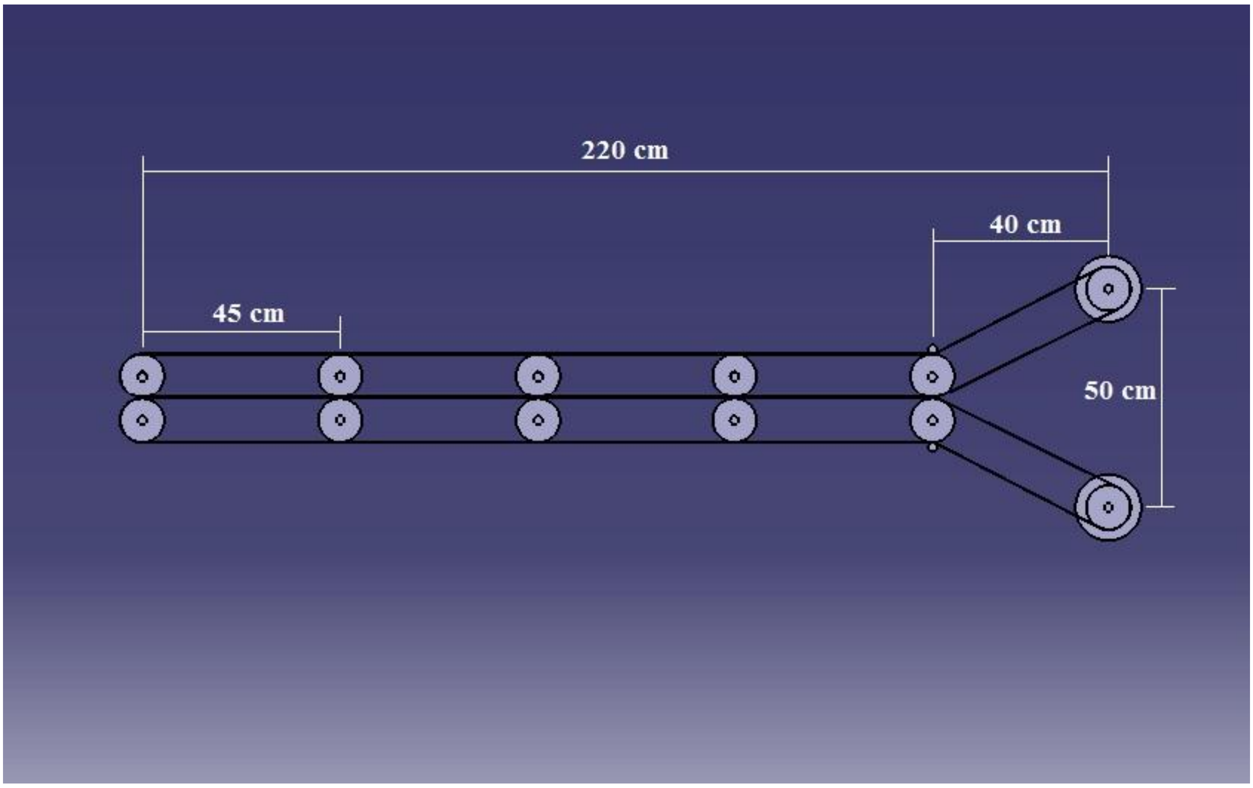


Figure (5.17): V-belt dimensions.

CHAPTER SIX

Electrical Design

6.5 Power Circuit design

6.6PLC Program

6.1 Design of the machine

The electrical design depends on the mechanical design, like choosing the motors for the applications, after making the calculations for the two systems in our machine, we decides what we need to use in the machine.

General design of the machine:

The design of the machine, in general, contains two systems with five motors.

- The first system is the Brushes system, this system will turn on using two motors. There is two stages of brushes, one is vertical and the other is inclined. Every stage will rotate by its own motor. The brushes will split the thyme leaves from the branch. In addition we will use a frequency converter with a rated power of 1 horse power to control the speed of the motors in this system, so that we can control the speed to be the minimum and keep the torque suitable for the application. From the mechanical design and calculations we will use 2 Induction Motors with a 0.25 horse power each (185 watts). The frequency converter will have the ability to turn on the two motors at the same time.

- The second system is the V-Conveyor with a lift conveyor. This system consists of two belts close to each other and a lift conveyor as a first stage. The Lift conveyor will deliver the thyme to the V-Conveyor. There will be a motor for the lift conveyor & two motors that will spin the belts of the V-Conveyor. This conveyor will take the thyme from the lift conveyor and deliver it to the first system (Brushes) to do their work. We will use another frequency converter with a rated power of 2 horse power to control this three motors because the speed of the Lift conveyor will equal the speed of the V-Conveyor. Depending on the calculations we will use three identical induction motors with a 0.5 horse power each (370 watts).

6.2 State Graph

The state graph is illustrated in figure 6.1 and the next section is explain it in details.

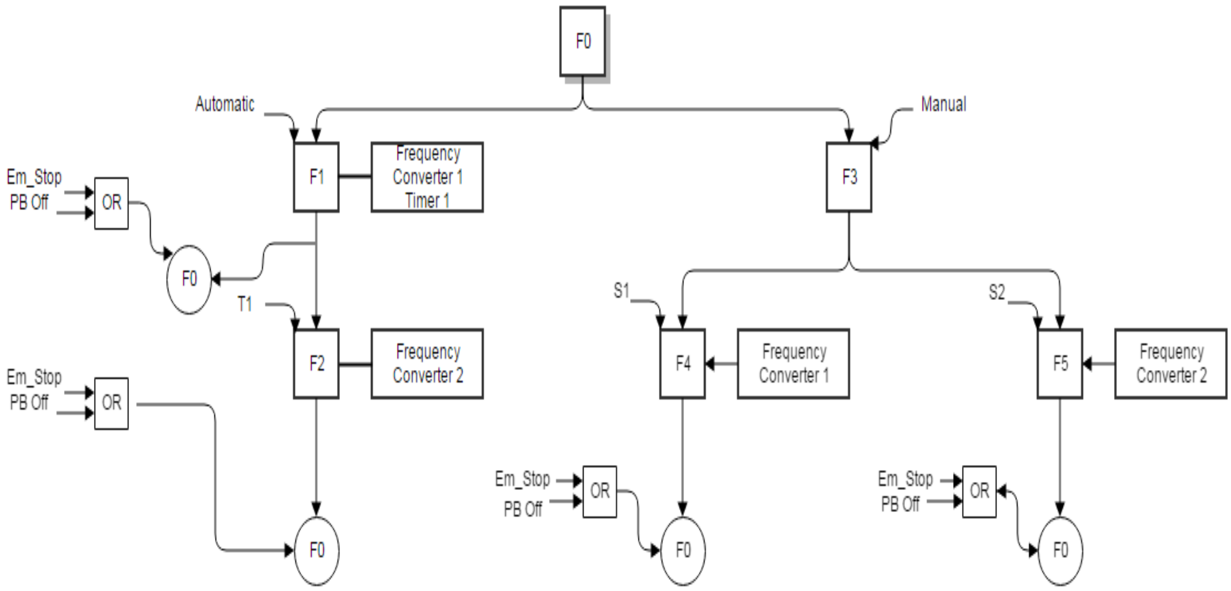


Figure (6.1): State graph of the machine.

6.2.1 State graph explanation

After pressing the (Start) push button, the initial step will be activated but with no action. Depending on the user of choosing between two kinds of operating using a three position switch on the electrical panel, automatic operating (F1) or manual operating (F3). If the user choose automatic operating the system will activate first step (F1) to turn on first contactor, so that the first frequency converter will be turned on, and that will lead to activate two motors for the first system (Brushes) with a timer. The system will continue and after the delay from timer 1 (T1), it will activate second step (F2) to turn on the second contactor, and that will lead to turn on the second frequency converter and activate the other three motors beside the brushes motors. There is a possibility to stop any action by pressing the (Stop) push button or the emergency switch, if pressed one of this two switches, the system will return to initial step (F0).

If the user select the manual operating, the system will set the third step (F3). At this step, the user will select one of two switches to start any system. If the user selects the first switch (S1), the system will set up fourth step (F4) to turn on the first frequency converter which will lead to turn on the two motors of the first system (Brushes). When selecting the second switch (S2), the system will set up step 5 (F5) to turn on the second frequency converter, so it will turn on the three motors of the second system (V-Belt Conveyor and the Lift conveyor). If the user want to turn off the system wherever it is, it can be done by pressing the (Stop) push button, active the emergency stop switch or to switch the selector to Zero, then the whole system will stop and go back to the initial step (F0),figure 6.2 and 6.3 explain where the processes are .

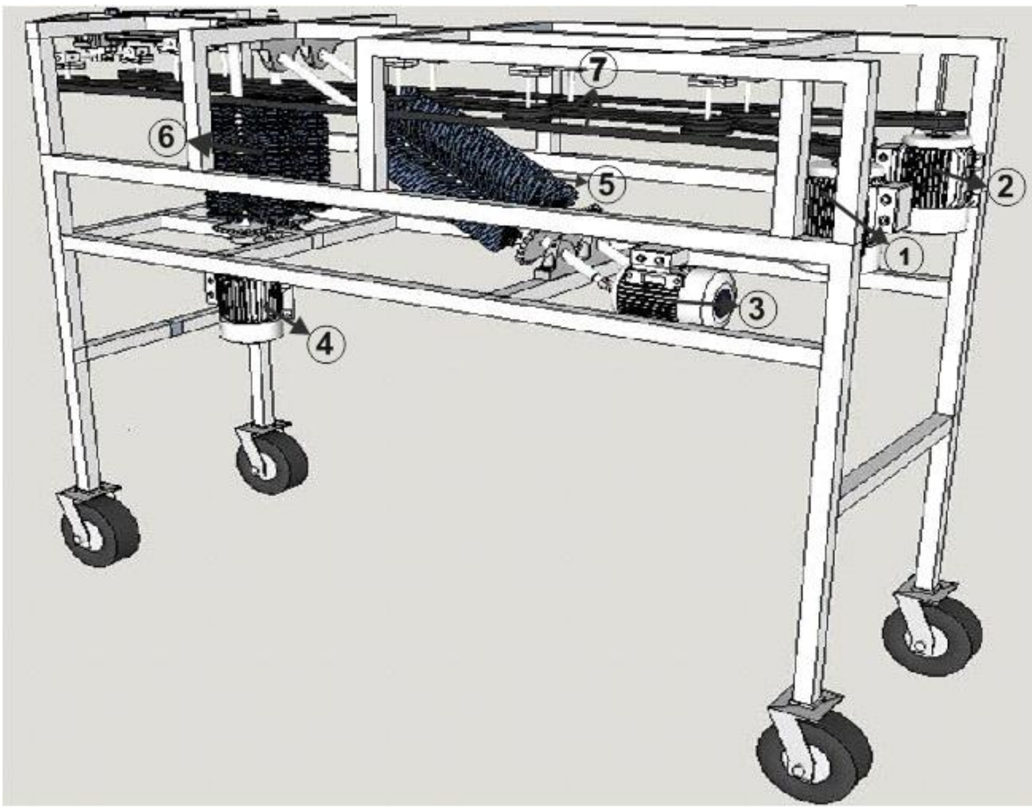


Figure (6.2): Design of the machine.

1. Motor 0.5HP.
2. Motor 0.5HP.
3. Motor 0.25HP.
4. Motor 0.25HP.
5. Inclined brushes.

6. Vertical Brushes.
7. V-belt.

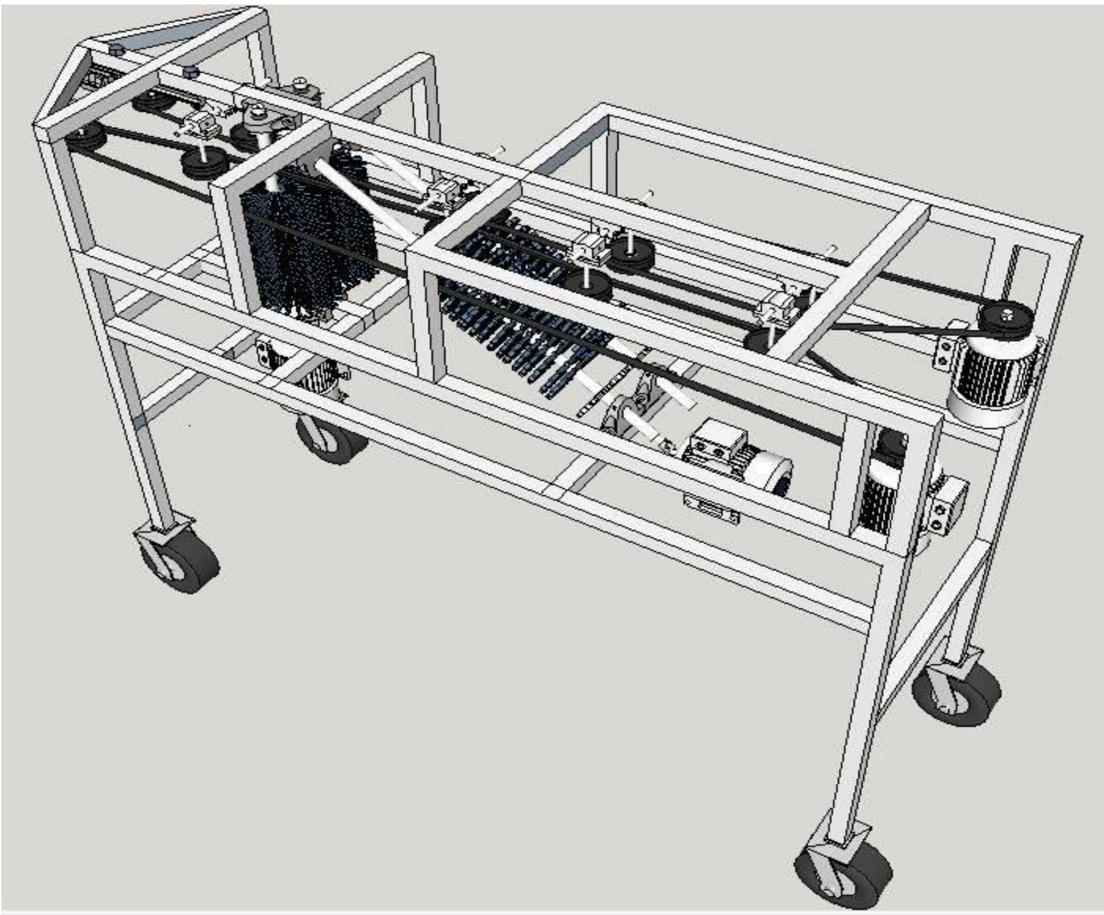


Figure (6.3): Top side of the machine.

6.3 Electric panel

Inside the electrical board there are 5 rows, in order to arrange similar devices in a single row.

First row has a Bus bar, Circuit breakers & the PLC.

- Busbar: It’s a distribution line, we used it to distribute the line cable and the neutral cable to the devices that needs AC power.
- Main Circuit Breaker: A protectrion device with a rated current of 16A.
- Residual Current Device: Protection device with a sensitivity of 30mA.
- Circuit Breaker: A protection device for the PLC and the Power Supply with a rated current of 6A.
- PLC “Fatek (FBs-24MAR2)”: A Control device that has a 14 inputs & 10 outputs.

Second row has the main mini-contactor, two power contactors & a power supply.

- Main mini-contactor: We will use this device to activate the PLC & the external power supply. It has a coil of 220V AC. It’s called the main because if it’s not activated the whole machine will stay off.
- Power Contactors: Each one of this contactors will be activated by a signal from the PLC, it has a coils that can work with a range from (20 to 60) VDC. We will use this contactors to run the Frequency Converters.
- Power Supply has an input of 220V AC and an output of 24V DC. We will use this power supply to protect the PLC & to provide enough power for the coils of the contactors.

Third row has the Frequency converters.

- Frequency converters will be used to control the speed of the motors. The first frequency converter will have a rated power of 1 horse power for the brushes system, the second frequency converter will have a rated power of 2 horse power.

Fourth row has theoverloads for the motors

- Overloads: We will use the GV2 overloads, because it has a Thermal Overload and a Current overload in the same device. This kind of overloads has a wide range and we can choose the overload depending on the rated current of each motor. Its much better than putting a thermal overload alone because it can be evaluated at the rated current of the motor, so we don’t need to put a another circuit breaker for each motor.

Fifth row has a Terminal Connectors.

- This connectors will be used to connect the main cable & the motor’s cables.

Fegures 6.3 is showing the conponant of electric panel.

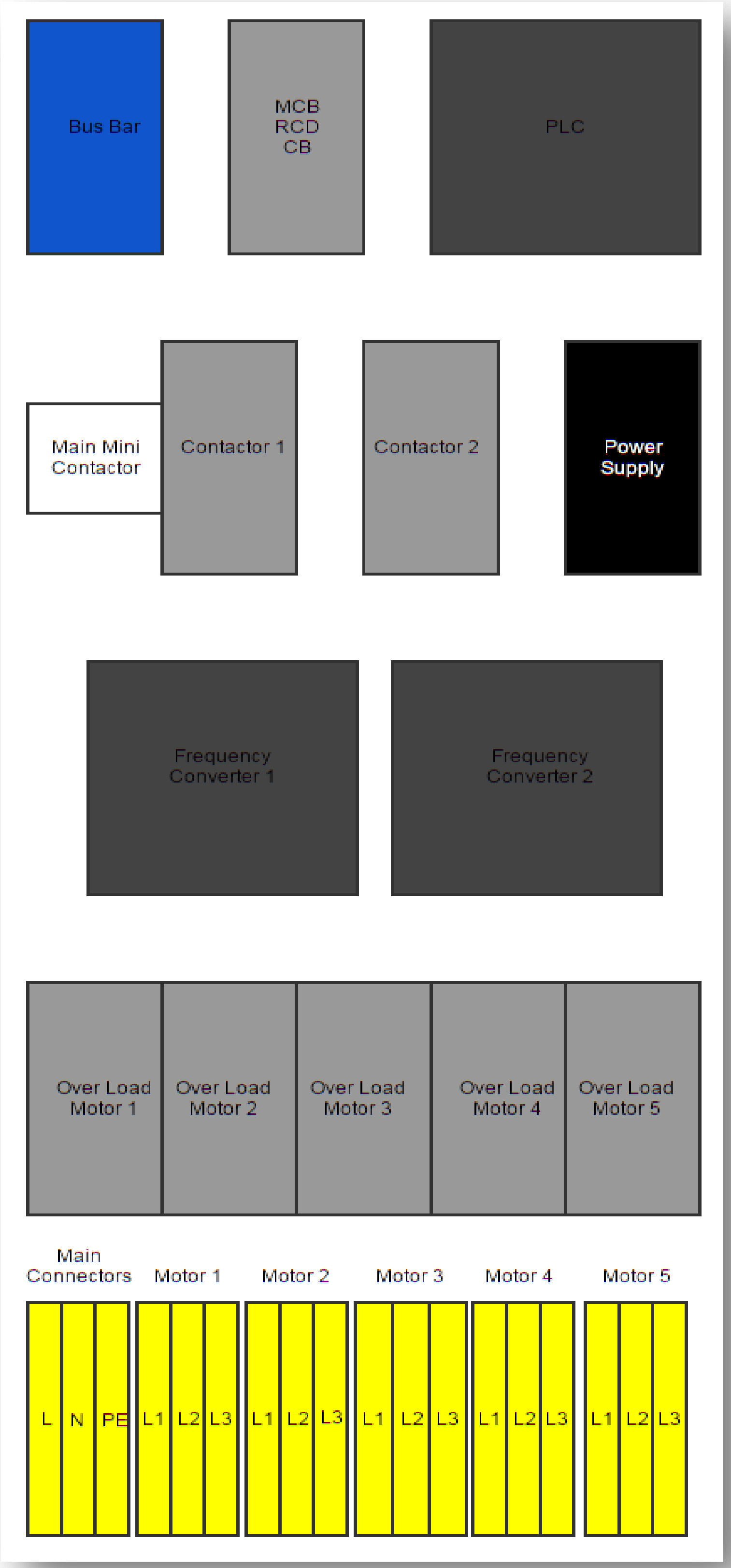


Figure (6.4): Interior design of the panel electric.

Outside the electrical board there are another 4 rows.

First row has a four detection lamps.

- First lamp will turn on when the PLC is active.
- Second lamp will turn on when system 1 is activated (Brushs System).
- Third lamp will turn on when system 2 is activated (The V-conveyor).

Second row has a selection switches.

- First Selector is a three position selection switch, it can let the user select the type of operating, Manual operatio, Automatic operation or stays at Zero.
- Second selector is a two position selection switch, it will be used in the manual operation to activate system 1 (Brushes system).
- Third selector is a two position selection switch, it will be used in the manual operation to activate system 2 (V-Conveyor and Lift Conveyor).

Third row has 2 push buttons.

- First push button (Green) is a normally open button, when the user push this button the PLC will turn on.
- Second push button (Red) is a normally closed button, it will turn off the machine if the user pushs it.

Fourth row has the emergency button only. When this button is pressed, it will turn off the PLC and the power supply.

Figuer 6.5and 6.6 illstrates the running panel.

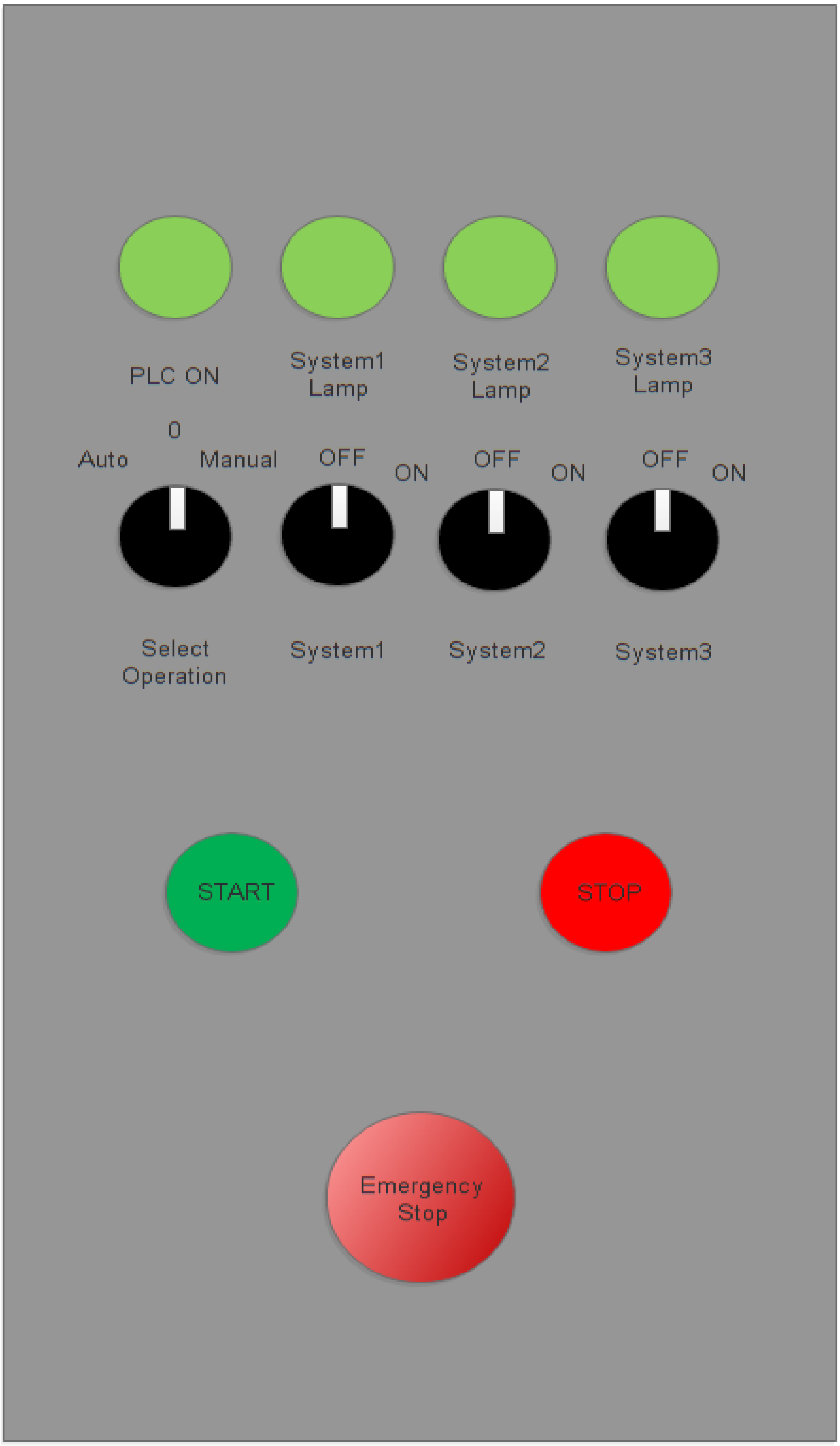


Figure (6.5): Exterior design of the panel electric.

Figure (6.6): Actual panel electric from outside.

6.4 Control circuit design

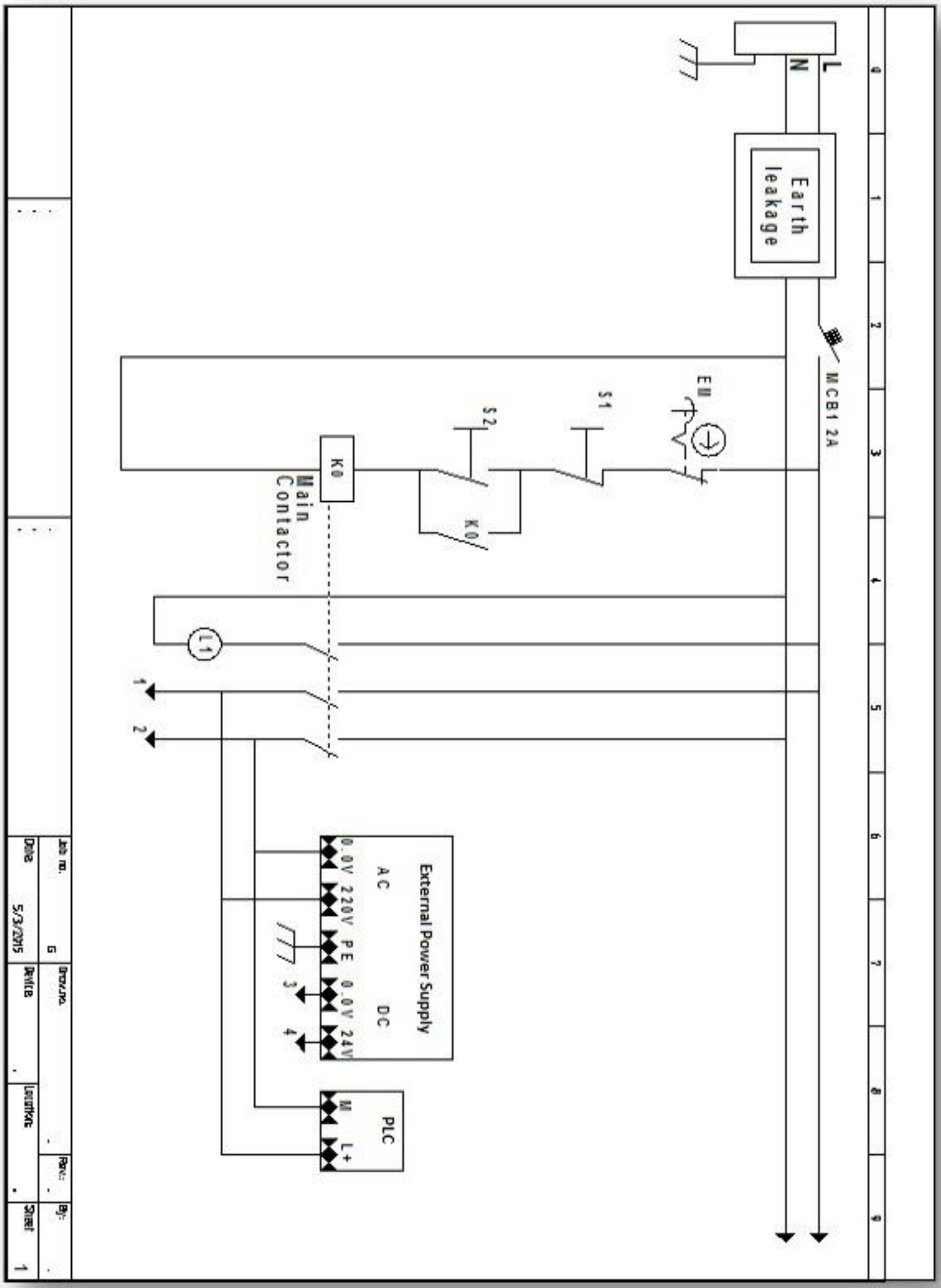


Figure (6.7): Main control circuit.

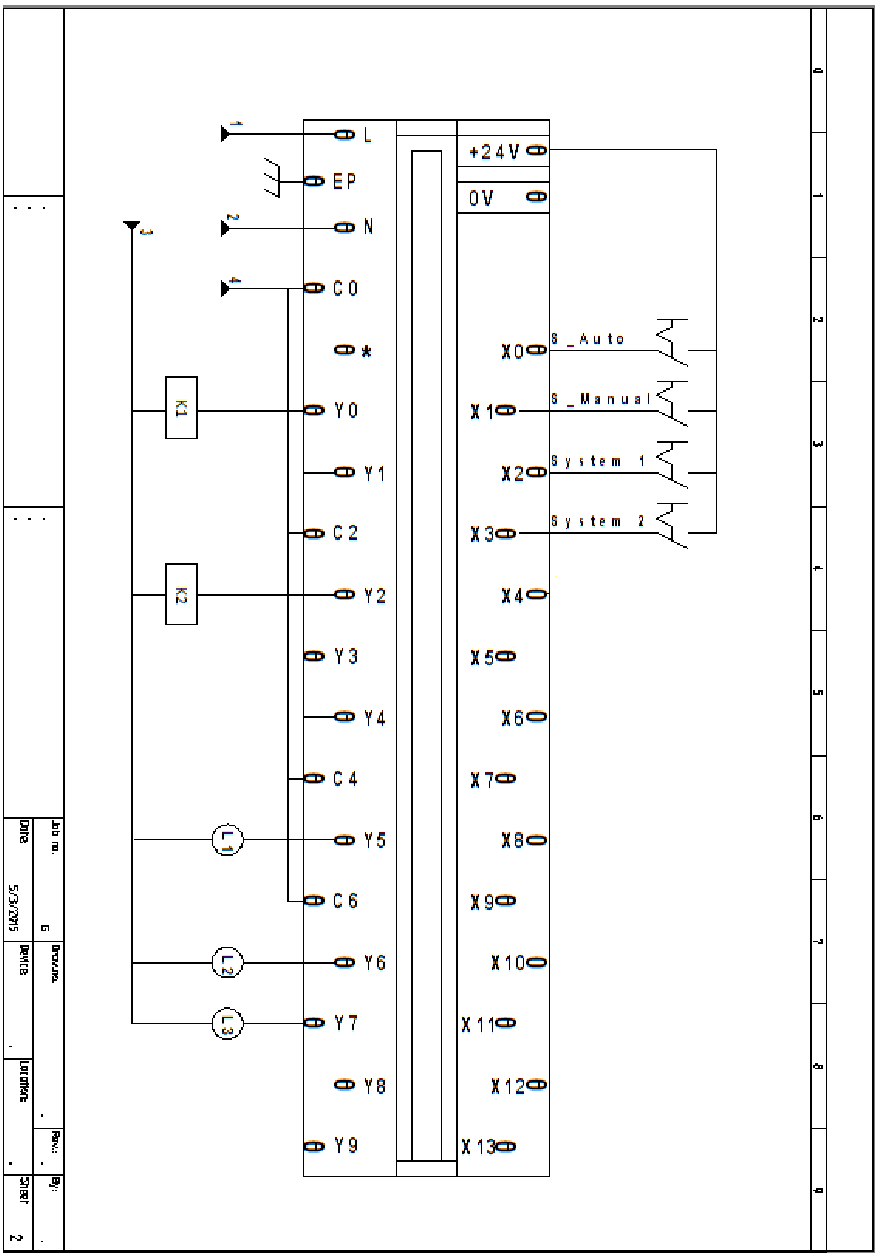


Figure (6.8): Connections of inputs and outputs with PLC.

6.4.1 Symbol table

Table (6.1): Symbol Table for PLC inputs and outputs.

Symbol number	Symbol	Address	Comment
1	Select Automatic	X0	Turn on automatic process
2	Select Manual	X1	Turn on manual process
3	System1_ON	X2	Turn on System1 (Manually)
4	System2_ON	X3	Turn on System2 (Manually)
5	Motor_1	Y0	Turn on motor 1,2 (Brushes)
6	Motor_4	Y2	Turn on Motor 3,4 (V-belt)
7	Lamp_1 (Brushes)	Y5	System1 is activated
8	Lamp_2 (V & Lift)	Y6	System2 is activated

6.4.2 Hardware Configuration

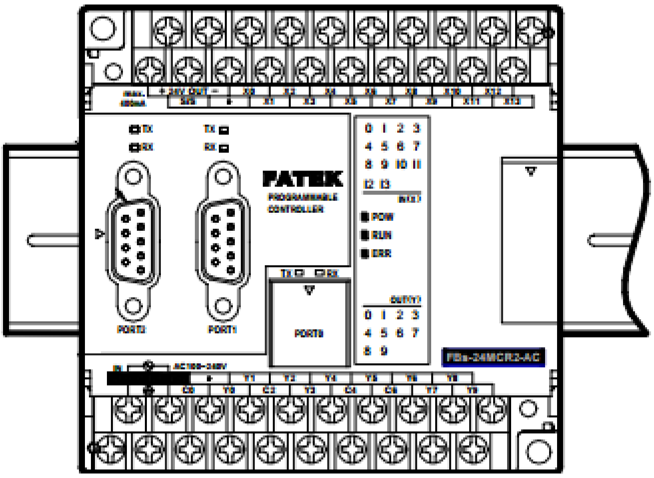


Figure (6.9): PLC Hardware.

The “Fatek FBs-24MCR2” PLC has a 14 digital inputs, with 10 digital outputs. This device is good for our application because we don’t need more inputs or outputs. We used five inputs to control the operation with eight outputs to turn on the contactors & to turn on the lamps in front of the electrical board.

6.5 Power Circuit design

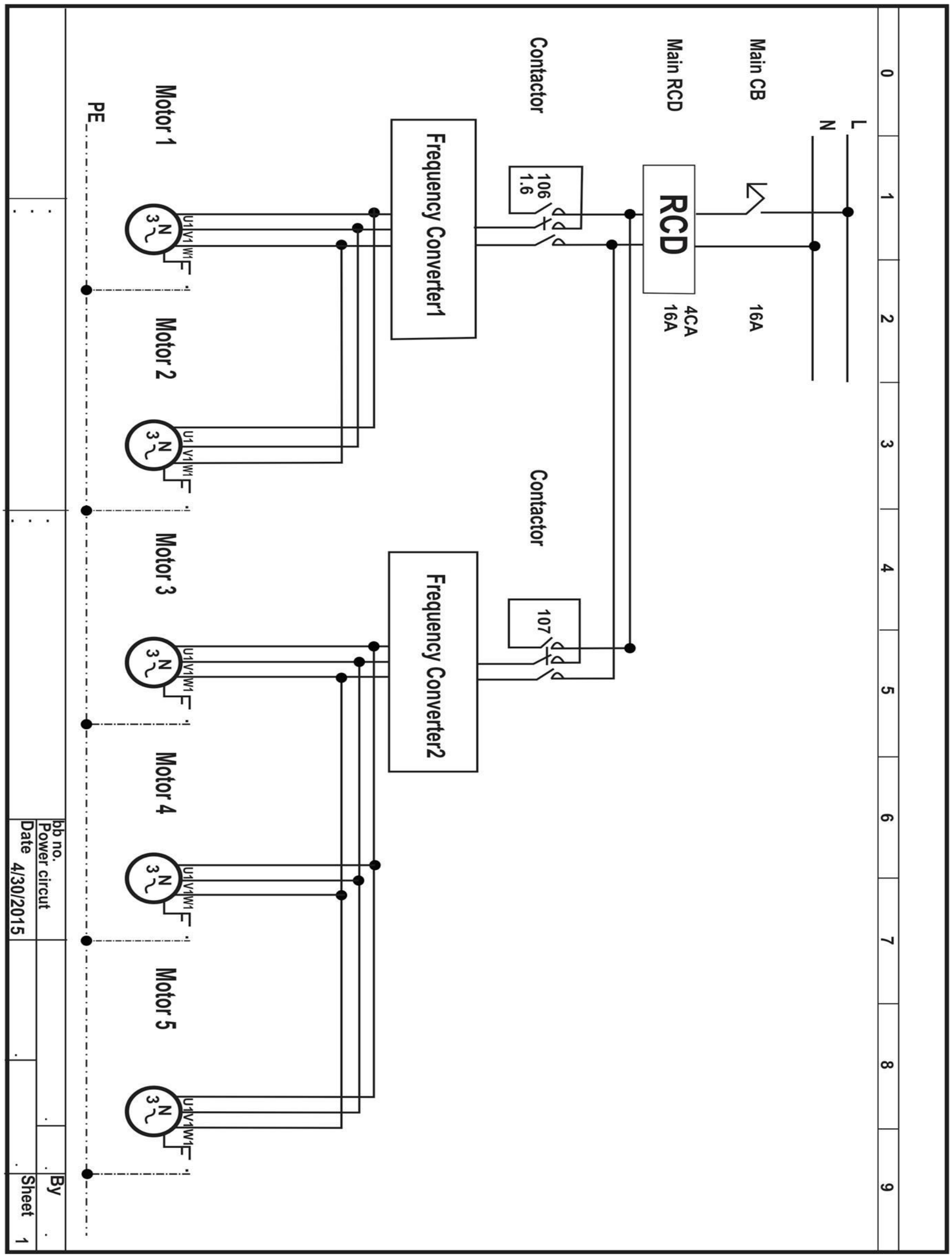


Figure (6.10): The power circuit.

Since the motors are three phase motors, we will use a frequency converters to control the speed of these motors. Depending on the full load rated currents of all the motors we will use a 16A circuit breaker as a main circuit breaker. Then there comes the residual current device, which is a two polebreaker, it is important to protect the user if there is any leakage in the circuit or in the motor's coils. If the leakage is more than 30mA it will switch off & the whole circuit will stop working.

In our panel; since we have a power circuit with a control circuit, we used 5 colors of cables with a thickness of 1.5mm. The main cable for the whole machine will have a thickness of 2.5mm, because this cable can carry as maximum 16A and with all motors are turned on with the maximum rated current, the sum of currents for the five motors will be only 9A. The colors will be brown for Line, blue for Neutral & yellow and green for the earth system. For the control circuit; we used two colors only. Red for the +24VDC & black for the Zero DC. This two cables will deliver the DC voltage to the coils of the contactors and to the dedication lamps.

Contactors in our circuit will have a coil of 20-60 VDC, because the output voltage from the PLC is 24VDC, so we can deal with contactors without using any external device like a relay with a coil of 24VDC.

Overload, it has a thermal overload & current overload. We choose the suitable overload depending on the rated full current for every motor. The connection of the contactor with an overload will be like figure (6.11).

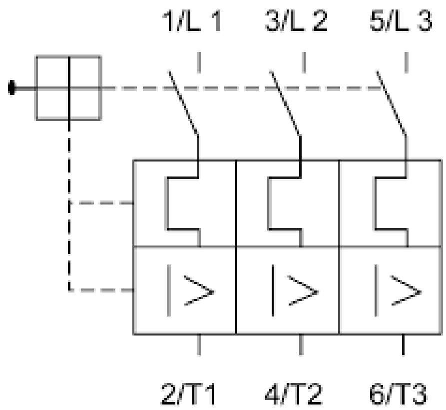


Figure (6.11): Three phase overload.

Frequency converters are used to change the frequency and magnitude of the constant grid voltage to a variable load voltage. Frequency converters are especially used in variable frequency AC motor drives.

Working Principle of Frequency Converters:

1) Convert from AC to DC "Converter": Through used six diodes we can convert AC voltage to DC voltage, they allow current to flow in only one direction.

As shown in figure (6.12); when A-phase voltage is more positive than B or C phase voltages, then that diode will open and allow current to flow. When B-phase becomes more positive than A-phase, then the B-phase diode will open and the A-phase diode will close. The same is true for the three diodes on the negative side of the bus. Thus, we get six current “pulses” as each diode opens and closes.

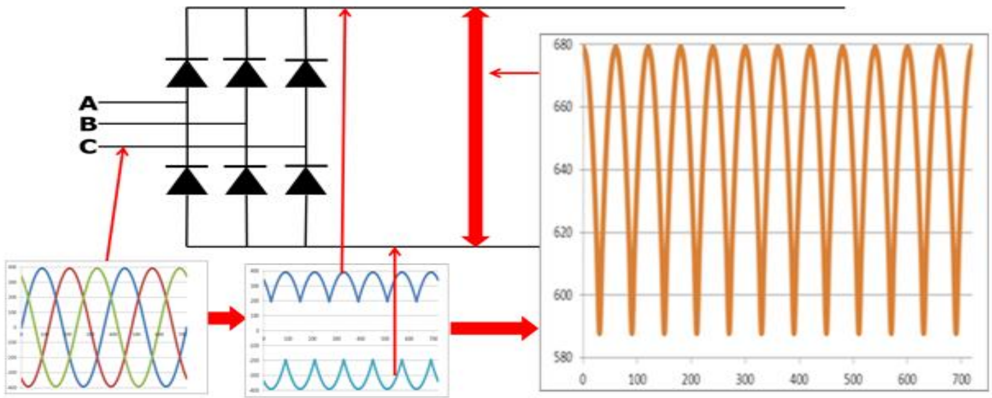


Figure (6.12): Convert from AC to DC "Rectifier".

2) DC Bus figure (6.13): We can get rid of the AC ripple on the DC bus by adding a capacitor. This capacitor absorbs the ac ripple and delivers a smooth dc voltage.

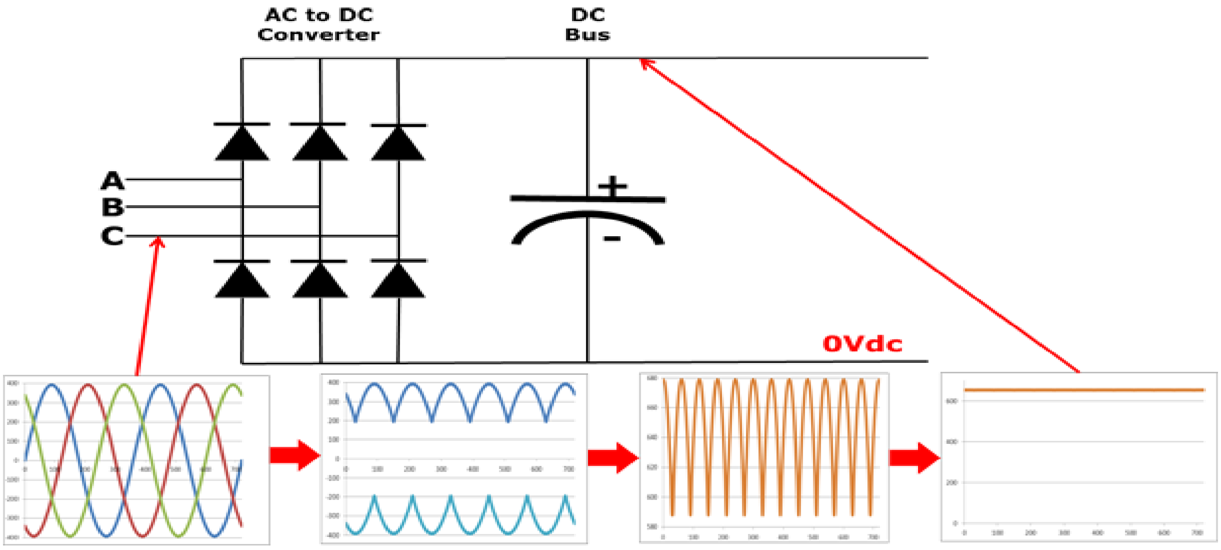


Figure (6.13): DC Bus.

3) Convert from DC to AC "Inverter": Through used six transistors we can convert DC voltage to AC voltage, they allow us to make any phase be positive, negative, or zero. It control by pulse width modulation as shown in figure (6.14). . When we close one of the top transistors in the inverter, that phase of the motor is connected to the positive dc bus and the voltage on that phase becomes positive. When we close one of the bottom transistors in the converter, that phase is connected to the negative dc bus and becomes negative. Thus, we can make any phase on the motor become positive or negative at will and can thus generate any frequency.

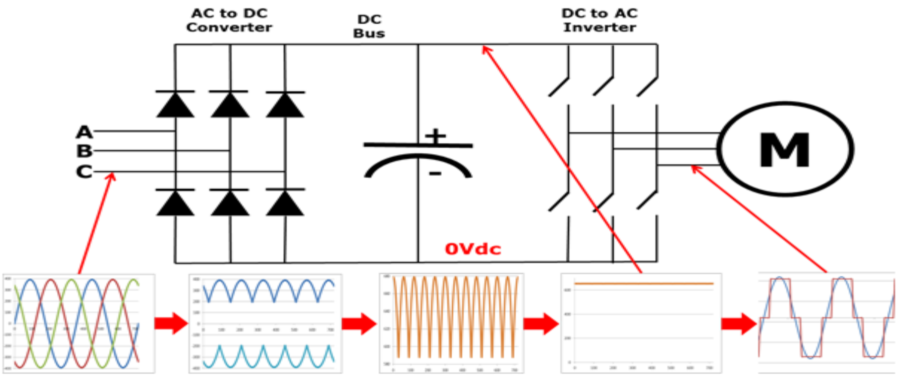


Figure (6.14): Convert from DC to AC "Inverter".

Frequency Converter is an important part in any electrical drive system, it have many benefits, including:

1. Reduce Energy Consumption and Energy Costs: Electric motor systems are responsible for more than 65% of the power consumption in industry today, any application that does not need to be run at full speed, and then you can cut down energy costs by controlling the motor with a frequency converter.

Optimizing motor control systems by installing frequency converter can reduce energy consumption in your facility by as much as 60%. Additionally, the utilization of frequency converter improves product quality, and reduces production costs.

2. Increase Production through Tighter Process Control: By operating your motors at the most efficient speed for your application, fewer mistakes, and production levels will increase.

3. Extend Equipment Life and Reduce Maintenance: The frequency converter will offer better protection for your motor from issues such as:

A) Phase protection" under voltage & overvoltage".

B) Electro thermal overloads.

C) Phase failure.

The specification of the used inverter is illustrated in table (6.2).

Table (6.2): frequency inverter specifications.

Voltage Class			115V		230V			
Model Number VFD- L								
Applicable Motor Output (kW)			0.2	0.4	0.2	0.4	0.7	1.5
Output Rating	Rated Output Capacity (KVA)		0.6	1.0	0.6	1.0	1.6	2.7
Output Rating	Rated Output Current (A)		1.6	2.5	1.6	2.5	4.2	7.0
Output Rating	Max. Output Voltage (V)		3-phase corresponds to double input voltage		Three-phase corresponds to input voltage			
Output Rating	Rated Frequency (Hz)		1.0~400Hz					
Power	Rated Input Current (A)		6	9	4.9/1.9	6.5/2.7	9.7/5.1	*/9
Power	Input voltage Tolerance		Single phase 90~132V 50/60Hz		Single / 3-phase 180~264V 50/60Hz			3-phase 180~264V 50/60Hz
Power	Frequency tolerance		±5%					
Control Characteristics	Control system		SVPWM (Sinusoidal Pulse Width Modulation, carried frequency 3kHz~10kHz)					
Control Characteristics	Output Frequency Resolution		0.1Hz					
Control Characteristics	Torque Characteristics		Including the auto-torque, auto-slip compensation, starting torque can be 150% at 5 Hz					
Control Characteristics	Overload Endurance		150% of rated current for 1 minute					
Control Characteristics	Accel/Decel Time		0.1~600Sec. (can be set individually)					
Control Characteristics	V/F pattern		V/F pattern adjustable					
Control Characteristics	Stall Prevention Level		20~200%, setting of Rated Current					
Operating Characteristics	Frequency Setting	Keypad	Setting by					
Operating Characteristics	Frequency Setting	External Signal	Potentiometer-5KΩ/0.5W, DC 0 ~ +10V (input impedance 100KΩ), 4~20mA (output impedance 250Ω), multi-function inputs1 to 3 (3steps, JOG, UP/DOWN command), communication setting					
Operating Characteristics	Operation Setting	Keypad	Setting by RUN//STOP keys					
Operating Characteristics	Signal	External Signal	M0,M1,M2,M3 can be combined to offer various modes of operation, RS-485 communication port					
Operating Characteristics	Multi-function Input Signal		Multi-step selection 0 to 3, Jog, accel/decel inhibit, first/second accel/decel switch, counter, PLC Operation, external Base Block (NC,NO) selection					
Operating Characteristics	Multi-function Output Signal		AC Drive Operating, Frequency Attained, Non-zero speed, Base Block, Fault Indication, Local/Remote indication, PLC Operation indication.					
Other Function			AVR, S-curve, Over-Voltage Stall Prevention, DC Braking, Fault Records, Adjustable Carried Frequency, Starting Frequency Setting of DC Braking, Over-Current Stall Prevention, Momentary Power Loss restart, Reverse Inhibition, Frequency Limits, Parameter Lock/Reset					
Protection			Over Voltage, Over Current, Under Voltage, Overload, Electronic thermal, Overheating, Self-testing					
Other			Including EMI Filter					
Cooling			Forced air-cooling					
Environment	Installation Location		Altitude 1,000 m or below, keep from corrosive gasses, liquid and dust					
Environment	Ambient Temperature		-10 -40 (Non-Condensing and not frozen)					
Environment	Storage Temperature		-20 to 60					
Environment	Ambient Humidity		Below 90%RH (non-condensing)					
Environment	Vibration		9.80665m/s^2(1G) less than 20Hz, 5.88m/s^2 (0.6Gat) 20 to 50Hz					

For the Brushes system we will use two motor with a rated power of 0.25 hp, we chose this motors based on the mechanical calculations in section (4.3.3). The overload for this two motors will have a range of (1.6-2.5 A).

Here is the place of this two motors, see figure (6.15):

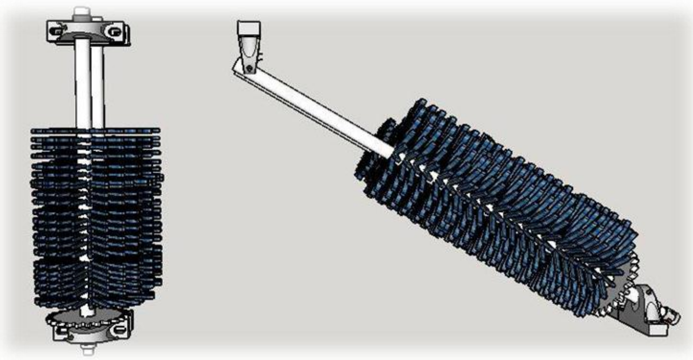


Figure (6.15): System 1- The brushes system.

For the V-Belt Conveyor system, we will use three phase AC induction motors with a rated power of 0.5 hp each based on the calculation in the mechanical design. The rated current for this motor is (2.1A). We will use two overload with a range of (1.6-2.5 A), and we will adjust it on 2.1A.

The two motors (Yellow) will be placed such as figure (6.16):

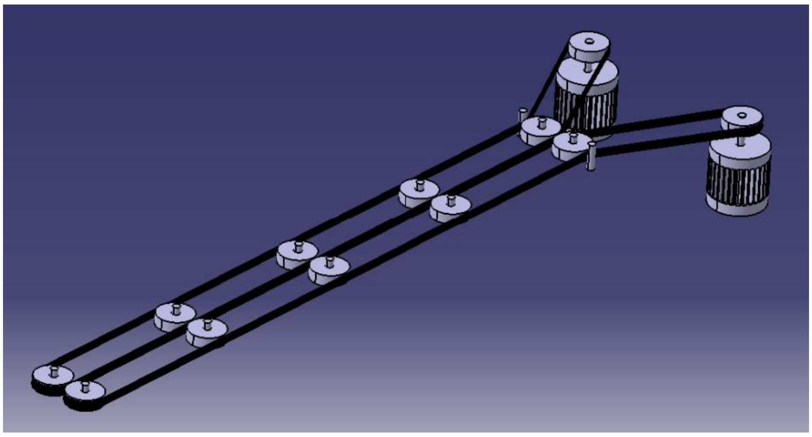


Figure (6.16): System 2 – The V-Belt Conveyor.

Before connecting any motor in our circuit, we connected the chassis of the machine with the main terminal connector for the earth cable, the same for the panel & the panel's door. The earth system is the most important protection system to protect the user of this machine, because the user will always be close enough to the chassis of the machine or to the panel board or maybe will be touching this parts.

6.6 PLC Program

Here, in figure (6.17) we will describe the program of the machine.

After pressing the Start push button there will be a choice for the user to select the automatic or the manual operation. When one of them is activated, there will be some conditions to activate each system & some conditions for protection.

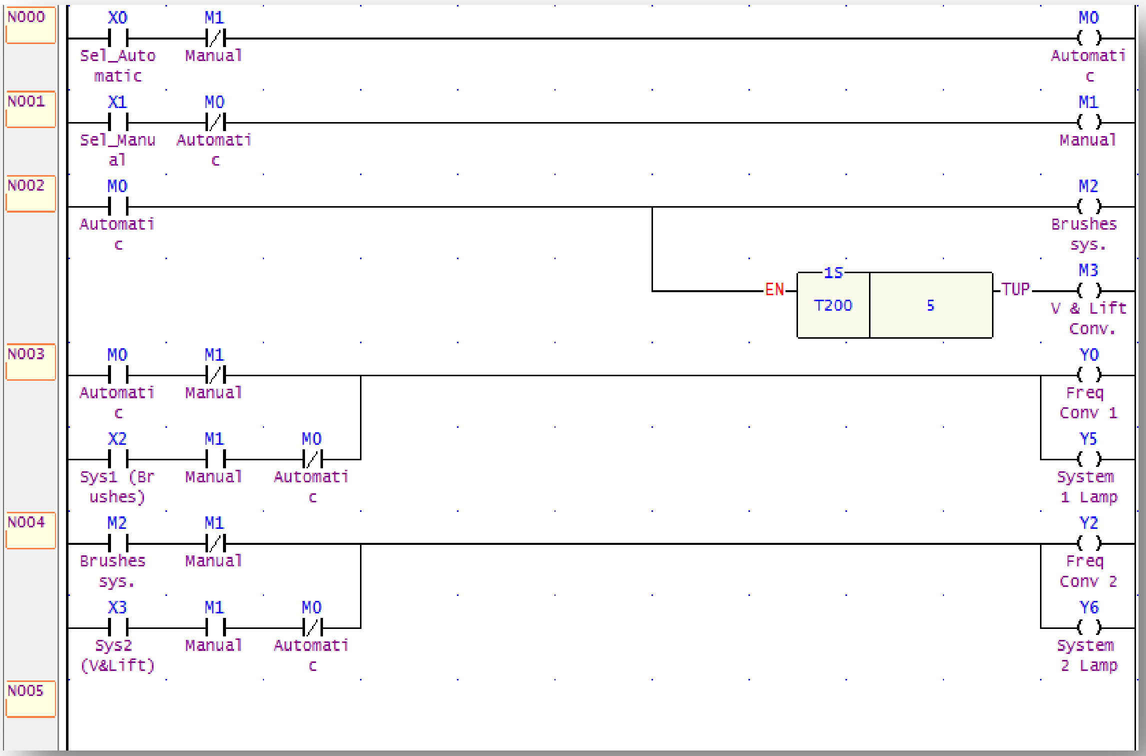


Figure (6.17): PLC Programming.

CHAPTER SEVEN

Productivity, Safety, and Maintainability

7.1 Introduction

This chapter will talk about productivity of the machine and comparing it with manual productivity. Moreover, the chapter will contain discussions about safety, efficiency, and maintainability.

7.2 Productivity

In manual method used nowadays, the worker work for eight hours daily to produce 240Kg of dry thyme (splatted thyme).

For thyme splitting machine, productivity calculations as the following:

V-belt will rotate at 100 rpm, so any point at the belt will move with linear velocity (ν):

$\omega = n\frac{2\pi}{60} = 100\ \frac{2\pi}{60} = 10.46$ rad/s

$\nu = \omega r = 10.46 \times 0.05 = 0.523$ m/s (r: Pulley radius)

That mean the one stack will move by velocity of 0.523 m/s, V-belt length is 180 cm, the needed time for stack to pass all the distance at V-belt is:

$t = \frac{L}{\nu} = \frac{1.8}{0.523} = 3.4$ sec

So, at one hour:

Number of stacks passed = $\frac{3600\ sec/hour}{3.4\ sec/stack}$ = 1050 stacks per hour

Stack weight is approximately 0.2 Kg, so:

Productivity per hour = 0.2 x 1050 = 210 Kg per hour

Since the machine will work eight hours per day, daily productivity will be:

Daily productivity = 210 x 8 = 1680 kg

So, Machine productivity is approximately 1.5 ton of dry thyme per day

In traditional method the worker split 240 Kg in one day, but this machine split 210 kg in one hour. “If there is a continuous feeding from worker to the machine”

7.3 Safety

- Cover:

The machine will be covered with transparent plastic from the upper part, while lower part will be covered with metal sheet.

This cover will protect the worker from dust, stem splinters, and prevent the worker from reaching the moving parts.

- Maintenance door (limit switch):

This door is mainly used for removing stuck thyme stems, the machine does not run while this door is open due to a limit switch that indicate whether its open or close, this door protect the worker from removing stems while the machine is running.

- Emergency switch:

In case any accident occurred this switch will stop the machine until the danger is removed.

- Overloads:

If there is any exceeding load, the motors will stop to prevent damaging the motor.

7.4 Maintainability

Machine parts will be joint together with screws and bolts to facilitate disassembling process for maintenance. Moreover, all of the machine parts are available in the market in case if any part is damaged it can be replaced easily.

All used screws have the same type and dimensions so it can be found and changed easily.

CHAPTER EIGHT

Result & Conclusion & Future work

8.1 Results and Conclusion.

8.2 Thyme splitting machine in final form

8.3 Future Work

8.1 Results and Conclusion

- In practical, the machine produces 25 Kg of dry thyme in 15 minutes, which mean about 100 Kg in one hour.
- Purity of leaves produced is about 50%pure leaves without stems.
- Separation of thyme ratio is about 60% separated leaves from the stacks.
- These experiments done at frequency of 15 Hz for brushes and 20 Hz for conveyors.
- Max frequency at brushes system inverter is 20 Hz.
- Max frequency at conveyors system inverter is 25 Hz.
- The idea of separate the leaves from stems one by one dose not succeeded , instead we separate leaves from stems as a stack.
- The machine could run without PLC as an advantage.

8.2 Thyme splitting machine in final form

The Thyme splitting machine in its final form shown in figures number 8.1 to figure 8.3

Figure 8.1.a splitting machine’s final form

Figure 8.1.b splitting machine’s final form

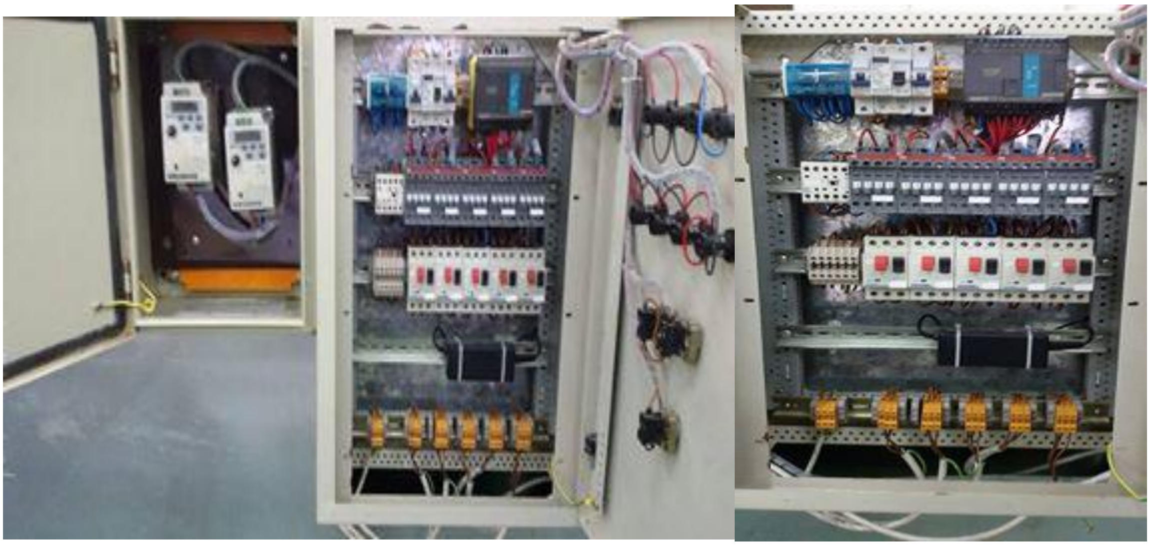


Figure 8.2 electric panel

Figure 8.3 user interface

Figure 8.4 side view of the machine

Figure 8.5 side view of the machine

Figure 8.6 front view of the machine

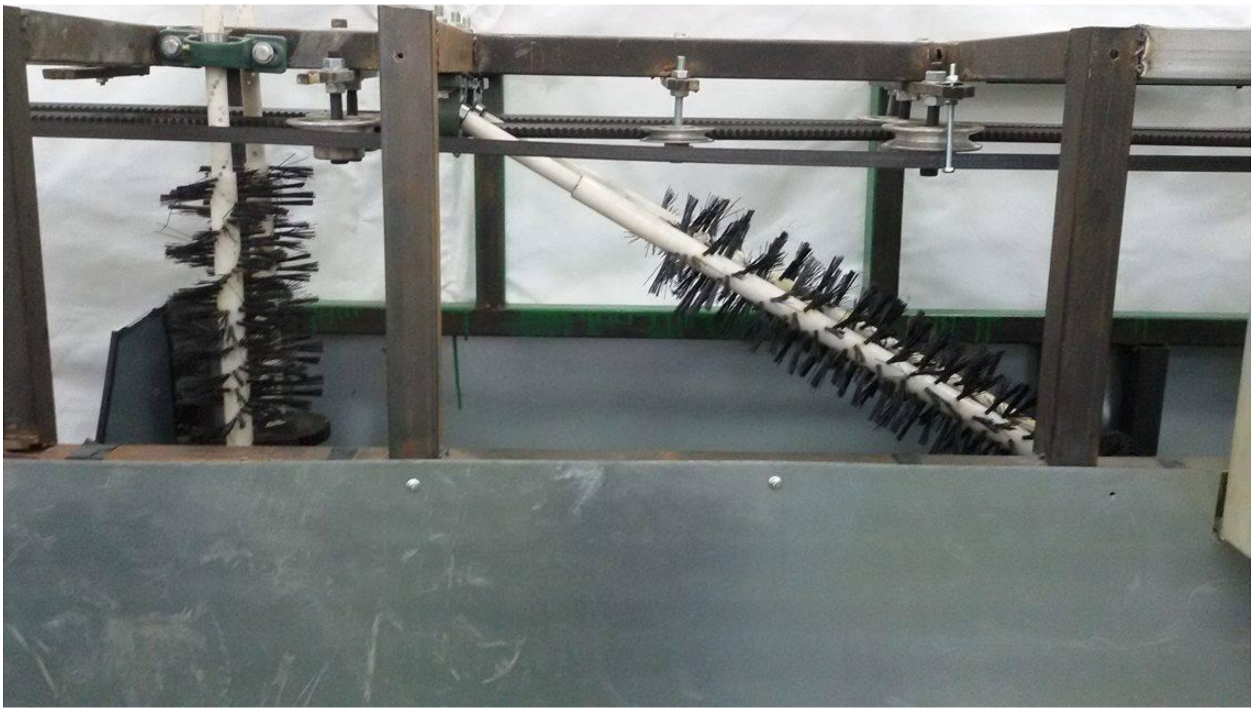


Figure 8.7 rear view of the machine

Figure 8.8 the left conveyer

8.3 Future Work

- Building the harvester machine.
- The ability to add other stage of brushes.
- Adjusting the angle of lift conveyor to be more suitable.
- Considering other system to be add in addition of brushes, to increase the percentage of separation.
- Changing the v-belt to be more suitable to catch the stems without falling.